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DEPARTMENT OF GEOLOGY

SURFICIAL GEOLOGY OF THE EDSON-HINTON AREA, ALBERTA

by



MURRAY ANDERSON ROED, B.A., M.A.

A THESIS

SUBMITTED TO THE FACULTY OF GRADUATE STUDIES

IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE DEGREE

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The undersigned certify that they have read, and recommend to the Faculty of Graduate Studies for acceptance, a thesis entitled "Surficial Geology of the Edson-Hinton Area, Alberta," submitted by Murray Anderson Roed, B.A., M.A., in partial fulfillment of the requirements for the degree of Doctor of Philosophy.

ABSTRACT

The Quaternary stratigraphy and glacial history of the Edson-Hinton area in west-central Alberta have been broadly resolved by reconnaissance field mapping and subsequent laboratory analyses. Informal rock stratigraphic units of both Cordilleran and Continental source have been established consisting of the Marlboro, Raven Creek, Obed and Drystone Creek tills of Cordilleran provenance, the Marsh Creek, Edson and Mayberne tills of Continental source, and the Mixed till deposited by combined Cordilleran and Continental ice. The Plante Creek and Pedley sediments, and Marsh Creek outwash are deposits of possible interstadial status and occur between till sheets. Three different gravel units of Pleistocene-Tertiary age underlie glacial deposits of the area and are here called the Tableland, Lowland and Buried Valley gravel, in order of decreasing age.

Laboratory investigations performed mainly on till were grain size analyses, pebble composition counts, heavy mineral identification, carbonate content and roundness of pebbles. These studies support the differentiation of the main stratigraphic units established by field mapping. Heavy minerals and carbonate content may be particularly useful in separating tills of Continental and Cordilleran source since hornblende occurs only in Continental units, and average carbonate content is 4 per cent in Continental tills as opposed to values of 11 to 45 per cent for Cordilleran tills.

Four and possibly five advances have been recognized. The oldest advance is inferred by fragmentary evidence of an "Early" Cordilleran till which may have been deposited by a piedmont glacier. The second glacier advance is the first and greatest advance of Continental ice into the area and is represented by the Marsh Creek till. Cordilleran ice may have occupied part of the Athabasca Benchland at

this time. Marsh Creek outwash overlies Marsh Creek till and was deposited in the ensuing glacial retreat. The third glacial advance was the more or less synchronous advance of both Cordilleran and Continental glaciers. The contact between the deposits of these two glaciers ascends at least 1000 feet in elevation which provides positive evidence that the two glaciers were in contact. The Cordilleran ice is recorded by the Marlboro and Raven Creek tills, and the Continental ice by the Edson and Mayberne tills. The Mixed till is the deposit laid down by the mixed parts of these two glaciers. The fourth glacial advance is documented by the Obed till of Cordilleran source which rests upon interstadial deposits of the Pedley and Plante Creek sediments. The Hinton terraces were formed during the retreat of the Obed glacier. The fifth and youngest glacial advance is tentatively recognized in the presence of the Drystone Creek till which occurs in small valleys at the mountain front.

Radiocarbon dates are not available for the glacial deposits in the area, but relative ages have been established which suggest the following tentative ages and correlations. The Marsh Creek advance is correlated in general with the Altonian Substage and the Edson advance with the Woodfordian Substage of the Wisconsin in the Midcontinent region of the United States of America (Frye and Willman, 1960). The Marlboro, Obed and Drystone Creek Cordilleran ice advances are believed to represent the Early, Middle and Late Stades of the Pinedale Glaciation ("classical" Wisconsin) of the Rocky Mountain area of the United States of America (Richmond, 1965). Correlation of the inferred "Early" Cordilleran till is not attempted in this study.

The economic geology of the surficial deposits is important in the area specifically in relation to the occurrence of granular deposits and groundwater aquifers, and to aspects of engineering geology, forest productivity, recreational geology and agricultural development.

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The writer wishes to thank the officers and technical staff of the Research Council of Alberta for their help, encouragement and advice in the field and office, particularly Dr. L. A. Bayrock who suggested the thesis area and subsequently supervised the field work. Dr. R. Green and Dr. B. Mellon assisted the writer in many ways. Generous financial support and aid for field work, drafting and radiocarbon dates were also provided by the Research Council of Alberta. To my supervisor Dr. A. J. Broscoe, and my advisors, Dr. J. A. Westgate, Dr. J. F. Lerbekmo, Dr. H. A. K. Charlesworth, Dr. C. R. Stelck and Dr. S. Pawluk, University of Alberta, my sincere thanks for their guidance, advice and support in the field and office. I am especially grateful to Dr. A. J. Broscoe and Dr. J. A. Westgate for their endless and patient dedication during the preparation of the manuscript.

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INTRODUCTION

General Remarks

Surficial deposits of the Edson-Hinton area are a complex and diverse assemblage of sediments that record glacial advances and retreats of both the Cordilleran and Continental ice sheets. The purpose of this study was to map these deposits on a reconnaissance basis and to deduce an approximation of the glacial history of the area. Further, some attention has been given to economic geology of the surficial deposits.

Location and Area

The inaccessibility of the southwestern and northwestern part of the Edson map-area (83-F), allowed only 4,500 square miles of a total of the 6,000 square miles of the Edson map-area to be mapped. The map-area is shown in Figure 1 and is referred to in this study as the Edson-Hinton area. It is bounded on the west by Jarvis Lake valley, Jasper National Park boundary and the Foothills, and on the east the area is bounded by Longitude $116^{\circ}00'$. The northern boundary is defined by Latitude $54^{\circ}00'$, the Berland River and the Wildhay River, and the southern boundary is Latitude $53^{\circ}00'$. The limit of mapping is shown in detail in Figures 2 and 3.

Access

Field work was hampered by lack of access. The main access roads utilized while mapping are shown in Figure 4, but this map does not show all the seismic cutlines, some of which were travelled. Travel was mainly by 4-wheel drive vehicle, but other traverses were conducted on foot, by boat, Weasels

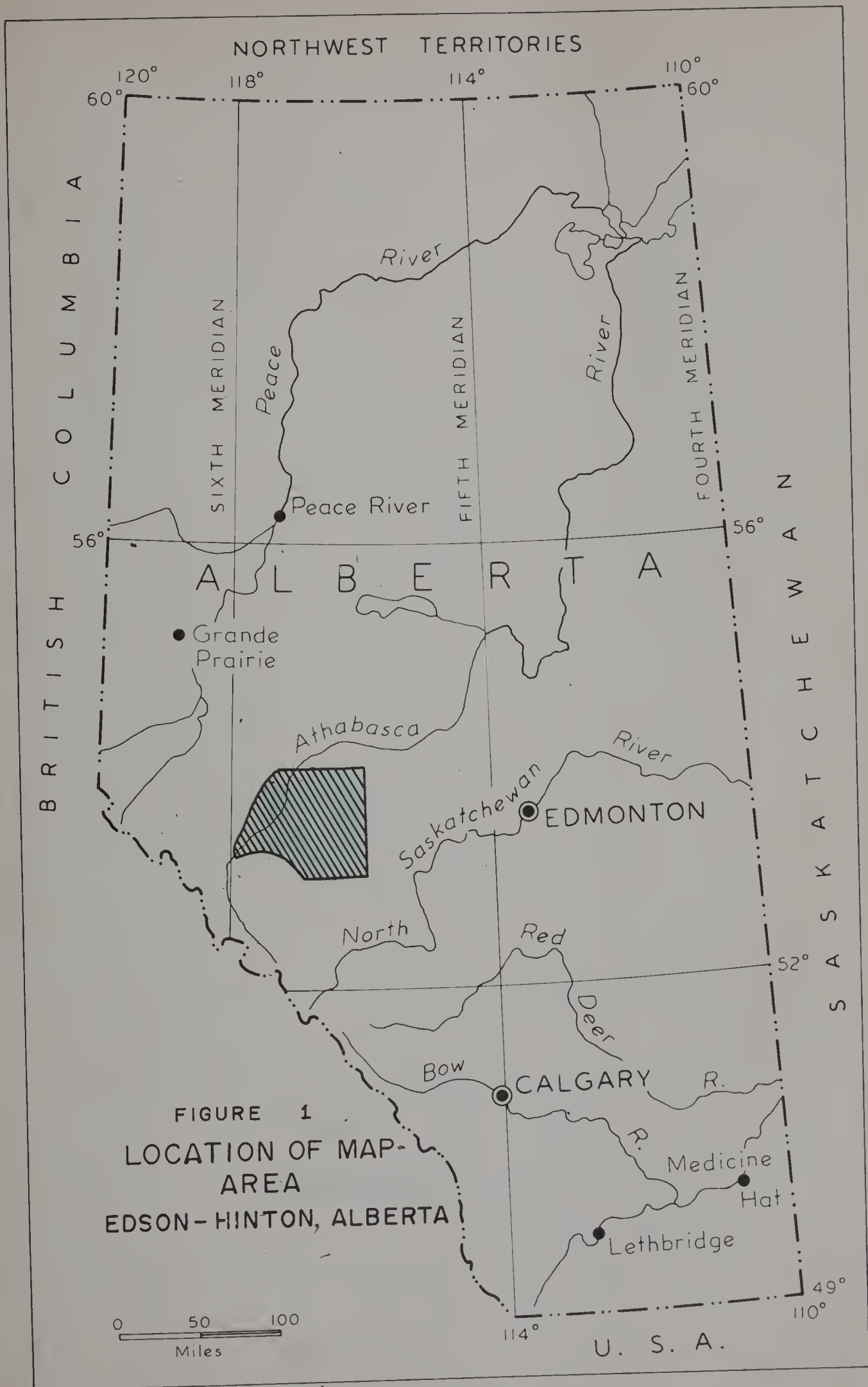
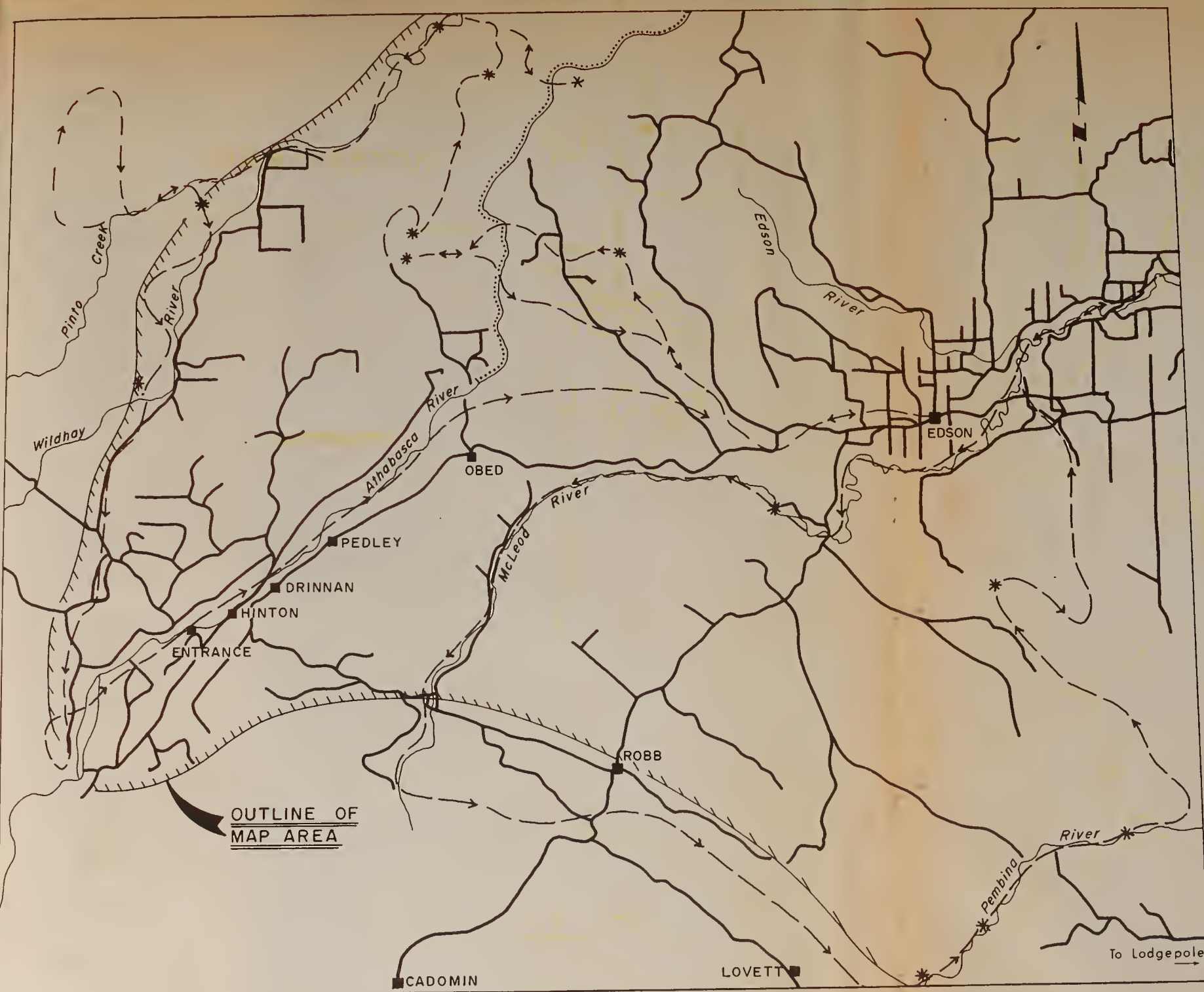


FIGURE 4

ACCESS MAP

- APPROXIMATE LOCATION OF MAIN ROADS
- - - HELICOPTER ROUTE
- * LOCATION OF STOP WITH HELICOPTER
- BOAT TRAVERSE DOWN ATHABASCA RIVER

0 miles 8



(bush-bikes), and by helicopter. Most of the entire area is covered with dense forest stands and extensive muskeg, and travel through much of this is difficult.

Field Work

Field Mapping

Three and one-half months during the summer of 1964 and five months during the summer of 1965 were spent in the field. The major criteria used for mapping were the lithology of the various surficial deposits, ice flow indicators and photographic expression. Outcrops are numerous even along seismic roads but rarely is a good section exposed.

A fundamental assumption employed in this mapping is that crystalline igneous and high grade metamorphic rocks found in the drift were all derived from the Canadian Shield. Except in the zone of mixing of Cordilleran and Continental ice (Figure 5), the occurrence of the above rock types is the best single criterion of a Canadian Shield source. Some metamorphic rocks have been derived from the Cordillera (Roed et. al., 1967), but these are mainly from a low to medium grade metamorphic facies and are very distinctive (Plate I, Figure 5, Table I).

The rock-color chart issued by the Geological Society of America (1963) was used in the field and laboratory for the description of the color of the various materials. The term "plastic" used for some materials described in this report refers to a measure of plasticity which was determined in the field by following the simple field tests outline by Means and Parcher (1963, p. 81 to 83).

Photogeology

Mapping was performed by interpreting aerial photographs and immediately

checking the interpretation of the deposits and landforms in the field. It was necessary to employ two different scales of aerial photos since photos with a scale of 1 inch = 3300 feet were taken prior to 1956 and do not show locations of new roads, whereas photos with a scale of 1 inch = 2640 feet were taken in 1963 and show most of the roads built in that interval of time. The larger scale photos, however, were used only for location purposes since the geomorphic expression of landforms is inferior on these photos compared to the resolution of the landforms on the 1 inch = 3300 feet photos. All information was therefore transferred to the 1 inch = 3300 feet photos which was in turn plotted on the excellent aerial mosaics (1 inch = 1 mile) of the area; then the information was traced onto an overlay which was reduced to 1 inch = 2 miles and transferred to the forestry base maps of the area (Figures 2 and 3) of the same scale.

It was not possible to use the aerial photographs to any great extent in the lithologic identification of the deposits, but photographs were extensively employed in the delineation of landforms in the area, such as alluvial fans, alluvial plains, glaciolacustrine plains, kames and eskers. Also, drumlins, grooves, flutings, lobate end moraines and lateral moraines were identified on the photographs and correlated with map units.

Although dense forest stands hampered photogeologic interpretation, after repeated checking in the field, the author quickly became accustomed to the characteristic geomorphic expression of the surficial deposits in spite of the tree cover. Many of the mapped contacts, however, are approximate in areas of difficult access since much photo interpretation was required and many of the boundaries delineated are gradational in nature.

Laboratory Work

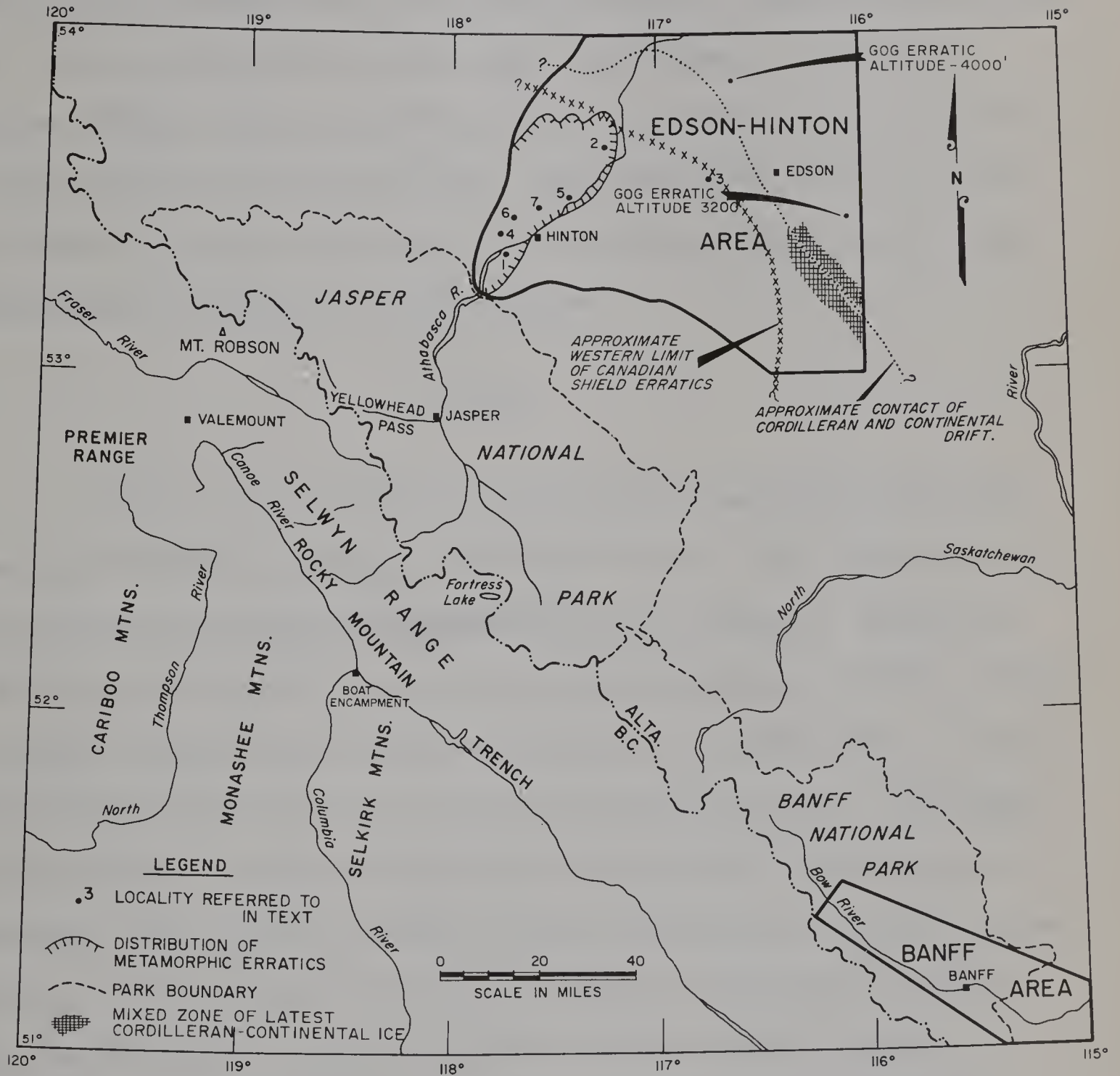
Laboratory work was conducted mainly on till, although several different gravel deposits were also studied. The principal objectives of the laboratory work were to describe accurately the surficial deposits, to gather information that might be used to correlate deposits, to determine the source of the deposits, and to describe the compositional variations of map units. The following characteristics were investigated: grain size distribution, pebble lithology, pebble roundness, heavy mineral composition, carbonate content, dolomite-calcite ratio and stoniness. Some grain size analyses of aeolian sand were done by the Alberta Soil Survey.

The techniques, tables, and other information about the laboratory analyses are included in Appendix A, but the principal result of the analyses on each of the rock stratigraphic units is incorporated into the description of the units under the section on stratigraphy.

Previous Work

There are no reports on the area which deal with the surficial geology in any detail. Most references are found in reports dealing with the bedrock geology which include Dawson (1890), Coleman (1910), Dowling (1910, 1911), Geological Survey of Canada (1913), Rutherford (1925, 1926, 1928), Kindle (1929), Lang (1947), and Mountjoy (1962, 1960). The work of early geologic explorers includes that of Hector (1863) who, as a member of the Palliser Expedition, first noticed glacial erratics west of Edson, and of McEvoy (1901) whose work is the most comprehensive of the early reports. Other papers which deal with special parts of the surficial geology are the following: Heusser (1956), Taylor (1958), Geological Association

of Canada (1958), Mountjoy (1958), Gimbarzevsky (1965, 1966), Williams and Bayrock (1966), Steen (1966), Roed et. al., (1967), Gabert and Roed (in press), and Roed (1965). General glacial features of the area have been included on the Glacial Map of Canada (Geological Association of Canada, 1958). Mr. Lee Slind, Shell Canada Ltd., mapped the landforms of the area in 1960 in order to coordinate geomorphic and glacial landforms with other factors in the exploration for hydrocarbons (personal communication); the report is a confidential company report and is not available for general distribution. An exploratory soil survey has been completed by the Research Council of Alberta (Lindsay et. al., 1963).



GENERAL LOCATION MAP SHOWING EDSON AND BANFF AREAS AND METAMORPHIC ERRATIC LOCALITIES OF THE ATHABASCA VALLEY ERRATIC TRAIN (See Table I) AND OTHER ERRATICS

PHYSIOGRAPHY

General Remarks

The Edson-Hinton area is located within the western part of the Interior Plains region and the eastern part of the Cordilleran region of western Canada (Bostock, 1948). The area is drained by four main streams: the Athabasca, and its major tributaries, McLeod, Pembina and Wildhay Rivers. The Athabasca River is part of the river system draining into the Arctic Ocean. Dense forest stands occur on all of the diverse landforms except the high ranges of the mountains and Recent alluvial plains; extensive tracts of muskeg occur in low-lying areas.

Climate

The area, because of its location east of the Canadian Rocky Mountains in west-central Alberta, experiences a continental climate. This is illustrated by the large annual and daily temperature ranges within the area (Figure 6). Summers are mild with the warmest month, July, having an average temperature of 58.7°F. Winters are long and cold; the average temperature for January, the coldest month, is 11.2°F. Monthly average temperatures from one year to the next differ greatly. The average annual precipitation at Entrance (Figure 6) for the period 1921 to 1960 inclusive, was 19.05 inches; large variations in monthly and yearly precipitation occur from one year to the next. Mild air masses lose most of their moisture in crossing the Cordilleran region, but still supply the greater amount of rainfall and snowfall in the area. Variations in aspect, exposure, slope, elevation and other factors within the area produce local differences in climate effects.

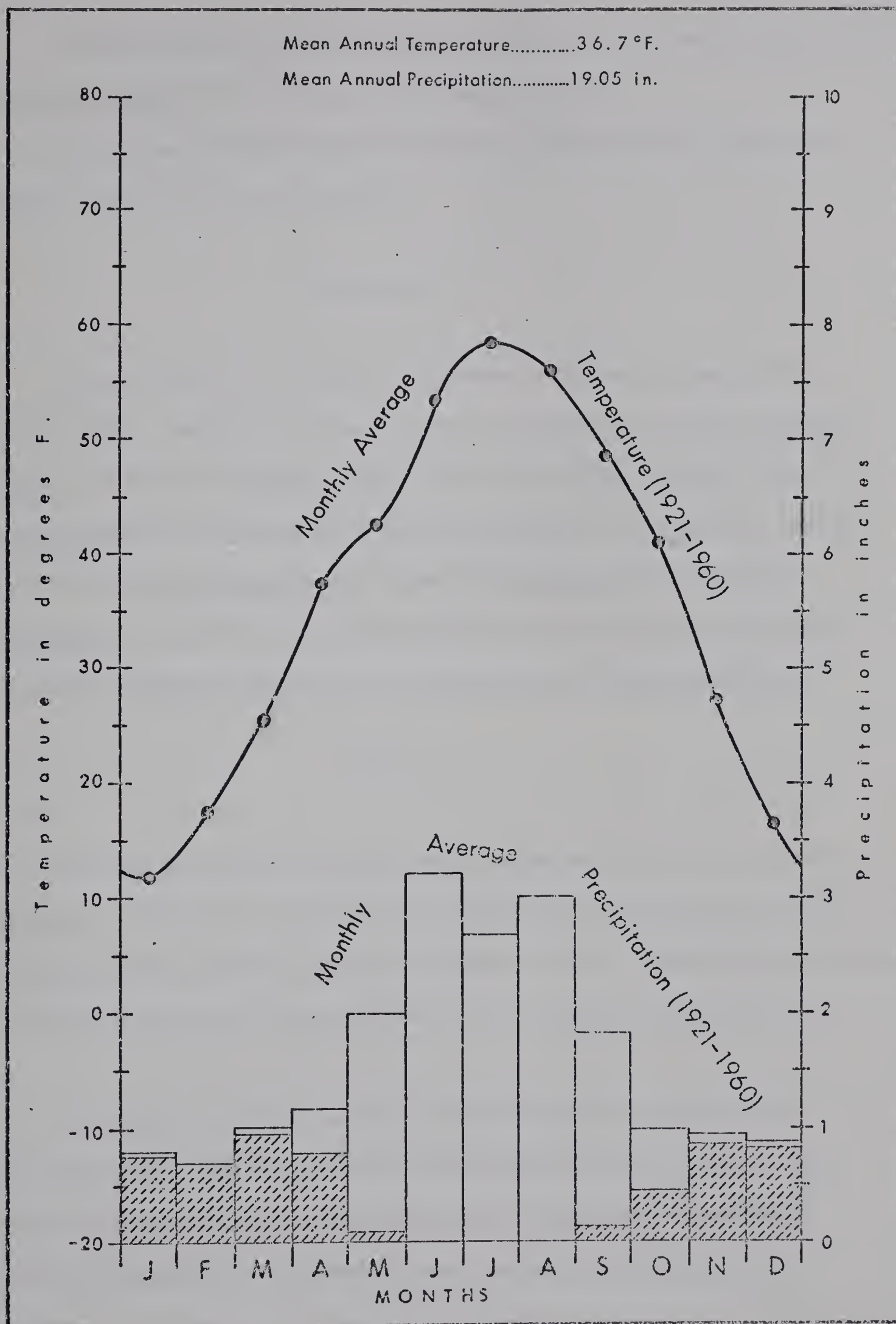


Figure 6. Climatic graph for Entrance compiled from records for the period 1921-1960. The blank bars represent rainfall; the dashed bars represent snowfall expressed as a rainfall equivalent.

In winter chinook winds affect the area, which result in temperatures 2 to 3 degrees warmer at Hinton than at Edson, sixty miles to the east.

The average frost-free period for 41 years is 48 days but the range over this time span is from 31 to 72 frost-free days.

Vegetation

The area occurs in the Boreal-Cordilleran Transition phytogeographic region (Moss, 1955). The distinctive tree species are lodgepole pine (Pinus contorta var. latifolia), white spruce (Picea glauca), black spruce (Picea mariana), aspen (Populus tremuloides) and balsam poplar (Populus balsamifera). Less abundant species include white birch (Betula papyrifera), tamarack (Larix laricina) and Alpine fir (Abies lasiocarpa). Most of the forest stands in the area are not more than 150 years old (D. Crossley, personal communication, 1964) because of frequent forest fires.

Soils

The soils of the Edson area have been mapped on an exploratory basis (Lindsay et. al., 1963) and are presently being mapped on a reconnaissance basis by the Soils Survey Branch, Research Council of Alberta (Lindsay, personal communication). Much of the following account was supplied by J. D. Lindsay, Research Council of Alberta.

Throughout the Edson area the soils are developed under forest and therefore under virgin conditions generally possess organic surface horizons (L-H), light colored eluviated horizons (Ae) and illuvial (B) horizons with accumulations of sesquioxides and/or clay. In general the parent materials or C horizons are calcareous.

A wide range of soil profiles occurs because of the variability in soil parent material, topography and climate. In the western portion of the area, the soils are developed on Obed and Marlboro till and generally belong to the Gray Wooded Great Soil Group (National Soil Survey Committee of Canada, 1963). In areas underlain by alluvial and outwash deposits the soils are for the most part Bisequa Gray Wooded. Similar soils are found in areas in which the soils are developed directly on sandstone bedrock.

In the valley of the Athabasca River in the vicinity of Entrance and Hinton the soils are developed on aeolian material that overlies till. The depth of the aeolian deposit is variable, ranging from a few inches to two feet or more. Morphologically these soils meet the concept of Brunisolic Gray Wooded soils; however, chemical analysis show them to have a relatively high soil reaction (pH) and a high exchangeable calcium status. Such characteristics are not normally associated with this type of soil development. It appears that the aeolian material being derived in part from the flood-plain of the Athabasca River to the west is high in calcium carbonate and has an effect on the chemical characteristics of the soils in this vicinity (Lindsay, personal communication).

The soils developed on Continental till are generally Gray Wooded although some Bisequa Gray Wooded soils have been observed in the stony Mayberne till to the north of Edson. The coarse textured soils associated with the dune sand in the vicinity of Edson are commonly Podzolic or Brunisolic in character.

Regosolic soils, those showing minimal horizon development, are confined mostly to low-lying recent river and stream deposits. Some regosols have also been noted on the steeper slopes in the foothills where soil creep may be retarding soil profile development.

Organic soils, those having more than eighteen inches of unconsolidated organic material at the surface, are found scattered throughout the map-area. They are most prominent in the Edson Lowland and Wildhay Benchland. A wide range of Gleysolic soils is evident in the poorly drained depressional areas and is of common occurrence throughout the area.

Physiographic Units

General Remarks

The Edson-Hinton area can be divided into three major physiographic divisions on the basis of geomorphology and geologic structure. These divisions are called (1) Rocky Mountain Front Ranges, (2) Rocky Mountain Foothills, and (3) Interior Plains. The Interior Plains of the area can be divided into local units referred to in this report as (1) tablelands, (2) benchlands, (3) lowlands, (4) Jarvis Lake valley, (5) buried valleys. Buried valleys should not be discussed under physiographic units, but they are included here for lack of a better section in the text. The major physiographic divisions are shown in Figure 7, the buried valleys in Figure 8, and a cross-section showing the general form of these units is given in Figure 9.

A generalized account of Pleistocene-Tertiary terrace levels recognized in the area is included in this section (Figure 10). Also a brief description of small-scale landforms of glacial and nonglacial origin is given, however, many of these landforms are mentioned under the section on stratigraphy.

The history of the physiographic development of the area is little known; the emphasis in this report is on late Pleistocene and Recent events.

Rocky Mountain Front Ranges

The Rocky Mountain Front Ranges consist of a number of northwesterly

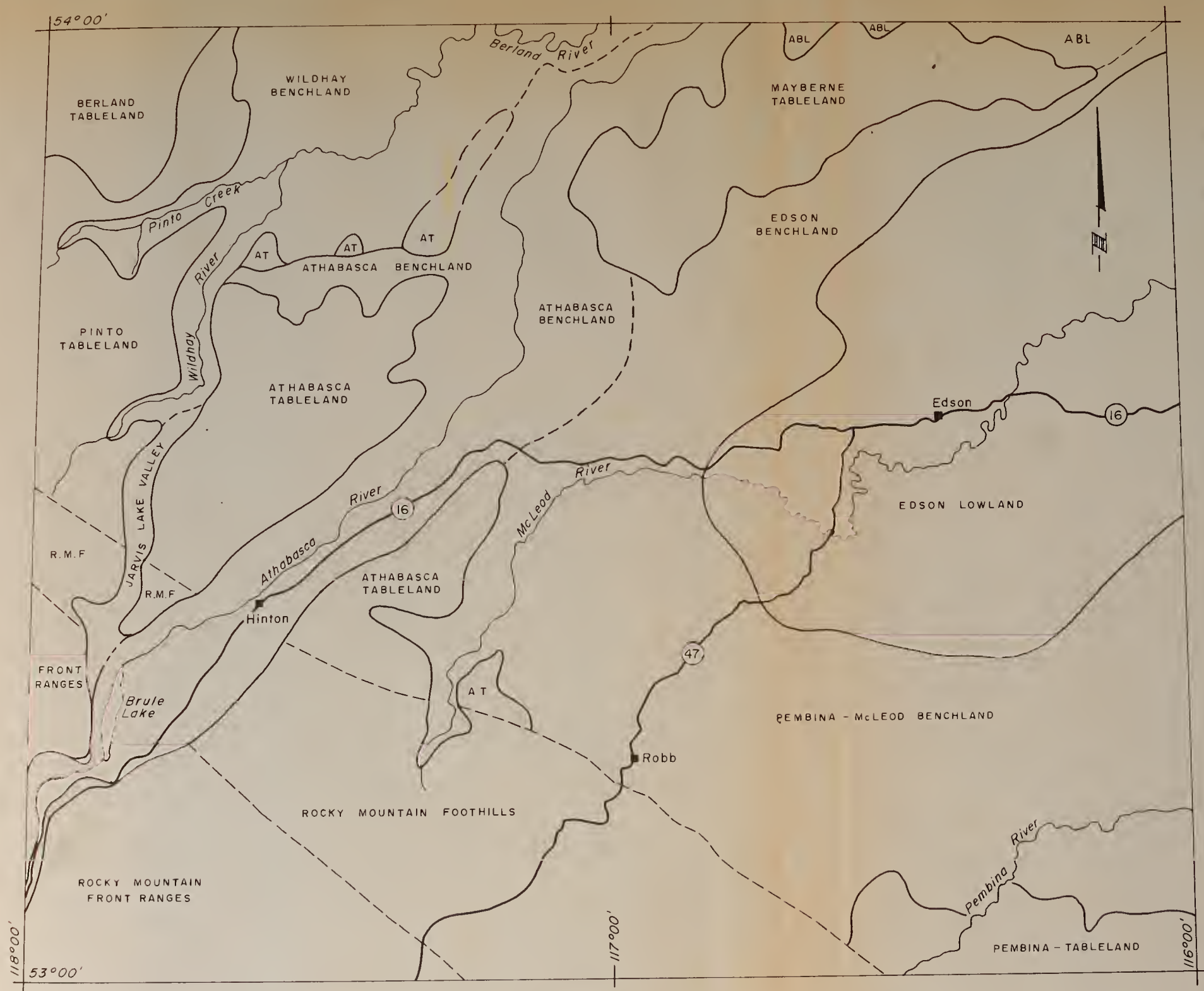


FIGURE 7

PHYSIOGRAPHIC MAP SHOWING MAJOR
PHYSIOGRAPHIC DIVISIONS OF EDSON AREA
(83-F)



trending ranges and valleys composed of a succession of overthrust sheets lying between southwesterly dipping faults. Resistant carbonate rocks of Upper Devonian and Carboniferous age form prominent ranges and less resistant sandstones and shales of Devonian to Cretaceous age form the valleys (Holland, 1964). Spectacular cliffs, u-shaped valleys and alpine sculpture characterize the Front Ranges, the high ranges of which are mostly bare of overlying surficial material. Thick drift deposits (Lang, 1947, p. 9) occupy some overdeepened valleys (Holland, 1964, p. 103).

Rocky Mountain Foothills

The Rocky Mountain Foothills lie along the eastern margin of the Front Ranges in a narrow, northwesterly trending belt. The Foothills are underlain by folded and faulted sandstones and shales that are Mesozoic in age. The western limit of the Foothills coincides with the trace of the Miette Thrust Sheet (Mountjoy, 1962, p. 52). The eastern margin of the Foothills is defined where sedimentary beds dip uniformly and gently to the east and is marked by the east flank of the northwesterly trending Prairie Creek Anticline (Lang, 1947, p. 40) in the vicinity of Hinton, and its structural equivalent such as the Pedley Fault (Irish, 1965). A structurally controlled trellis drainage pattern is developed only in the southern part of the Foothills in the area. In the northern part of the area, in the vicinity of Entrance, drainage bears very little relation to known structural grain. The Jarvis Lake valley cuts obliquely across folded structure and the Athabasca River flows at right angles to the structural trend. Another striking feature of the Foothills in the area is the presence of several poorly defined terraces; one occurs on High Divide Ridge and the other

forms the surface of Moberly Hill. These terraces are discussed in more detail under the section on Pleistocene-Tertiary terrace levels.

Interior Plains

General Remarks

The Interior Plains physiographic division is bounded on the west by the Foothills and makes up the largest part of the map-area.

Tablelands

The term tablelands has been applied by Bayrock (in Lindsay et al., 1960, p. 38) in Alberta to highlands which have relatively steep-sided slopes and flat tops. The term has been used in this sense for about a century (American Geological Institute, 1966, p. 291). Relative relief between lowlands and tablelands is generally from 1,000 to 2,000 feet in the area. Tablelands are commonly underlain by gravel deposits referred to as Tableland gravel. In most places this gravel can be related to a well-defined terrace, and the gravel rests upon bedrock and is overlain by glacial and Recent deposits. All parts of the tablelands in the area have been affected by glaciation. Thick drift deposits, meltwater channels, and other glacial features have only slightly modified the tablelands (Plate 3). Boundaries outlining various tablelands are not drawn along topographic contours; instead they are drawn so as to outline major landforms (Figure 7) that have a similar form characterized by similar geologic features. Tablelands that are recognized in the Edson area include the Athabasca, Pinto, Berland, Pembina and Mayberne Tablelands (Figure 7).

Benchlands

Benchlands are defined generally as areas between a tableland and a lowland and are characterized by remnant isolated terraces. This general definition is similar to benchlands described by Davis (1932, p. 432, figure 10). In the present area benchlands form a dominant feature of the physiography. Two or three distinct benches or ill-defined terrace levels (Plate 4) can be detected in most benchlands, an example of which is given in Figure 10. However, the terraces are always ill-defined and they have been modified considerably by glacial erosion. No gravel has been found on benchland terraces.

The terraces have been nearly completely removed from the Pembina-McLeod Benchland but are comparatively well preserved in the Edson Benchland. A striking example of a remnant terrace in the Pembina-McLeod Benchland is located in Tp. 49, R. 19 and 20. Three or more terraces are evident on aerial photographs above glacial terraces north of Hinton along the flank of the Athabasca Valley; the occurrence of these terraces provides the main basis for designating the Athabasca Valley as a benchland.

Lowlands

The only lowland outlined in the Edson-Hinton area is the Edson Lowland (Plate 5) which is characterized by low relief and occupies a low area relative to benchlands and tablelands. The lowland is underlain by deposits composed of gravel, till and glaciolacustrine sediments which rest on a bedrock surface of low relief. In places the bedrock crops out and in other places it is deeply buried beneath glacial

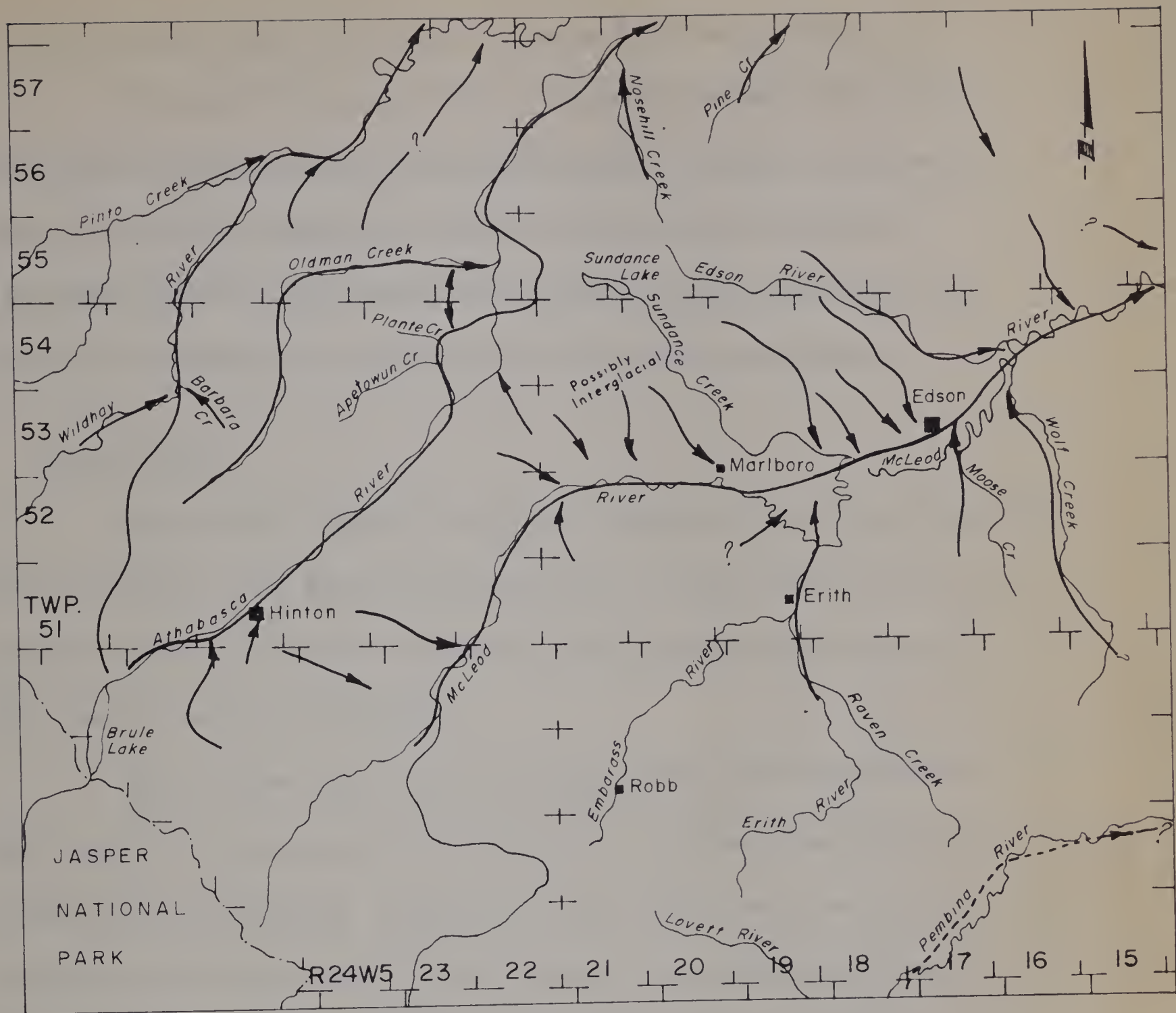
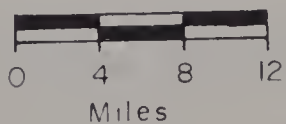


FIGURE 8

BURIED VALLEYS EDSON - HINTON AREA



and fluvial deposits, especially along the courses of buried valleys (Figure 8).

The gravel which occurs within the Edson Lowland above the general level of buried valleys is referred to as Lowland gravel. The gravel is believed to have been deposited by nonglacial or glacial streams during the development of the Edson Lowland. Lowland gravel occurs beneath glacial deposits and on top of bedrock. It is discussed in more detail under the section on stratigraphy.

Buried Valleys

Buried valleys (Figure 8) are valleys in bedrock that have been subsequently filled or partly filled with glacial and fluvial deposits. Gravel that occurs near or at the bottom of the buried valleys is called Buried Valley gravel and is discussed in detail under the section on stratigraphy.

Buried valleys occur in all of the physiographic units discussed above. Figure 8 outlines the courses and flow directions of some buried valleys in this area, but many more may be present. In general the buried valleys can be recognized by conspicuous surface depressions and as low reaches on topographic maps following present stream valleys, but detailed location of a buried valley can only be determined by drilling. Seismic shot-hole data have been employed to outline some of the buried valleys in the area.

Some buried valleys predate the earliest known Continental ice advance, such as those developed east of Edson, and some are believed to be related to the retreat of one of the Cordilleran ice advances, such as the southeasterly trending valleys southwest of Sundance Creek and possibly the buried valley located along the trend of

Jarvis Lake Valley. The age relationships of these buried valleys are not known accurately, but more than one development phase of buried valleys is obvious.

Jarvis Lake Valley

The Jarvis Lake Valley is so anomalous in relation to other physiographic divisions that it justifies a separate classification. It is continuous with the Athabasca Benchland and Wildhay Benchland but differs from them in that the Jarvis Lake Valley does not possess terraces nor even well-developed drainage pattern at present.

The origin of the Jarvis Lake Valley is not precisely known but consideration of some of its characteristics provides some insight into the possible complexity of physiographic development. This valley trends obliquely across the regional structural grain of the area, has relative relief of over 2,000 feet, is narrow compared to the broad Athabasca Benchland, and is rimmed by bare bedrock cliffs along much of its length. Lang (1947, p. 9) described a borehole drilled just north of Brule Lake which penetrated 944 feet of gravel before reaching bedrock, and in the vicinity of Gregg Lake, the drift is at least 200 feet thick (Michele Curcio, personal communication, 1965). The bottom of the valley is therefore suspected to be below the present level of the Athabasca River and may represent an overdeepened valley (Holland, 1964, p. 103), and could be classified as a partly buried valley as the term is used in this report. This fragmentary evidence suggests that the valley is glacial in origin and since the valley sides are mantled with Marlboro till (Figure 2), it may be related to an earlier glaciation.

Pleistocene-Tertiary Terrace Levels

Pleistocene-Tertiary terraces form flat parts (Figure 10) of tablelands, and remnant ill-defined terraces of the benchlands and some parts of the lowlands capped by Lowland gravel. Although one or more terraces can be recognized in most of the foregoing physiographic units of the area, only the terraces in the Mayberne Tableland, Edson Benchland and Edson Lowland are briefly discussed and are considered as representative for the area.

These terraces have been divided into five levels, I, II, III, IV and V from oldest to youngest, on the basis of the range in elevation of the upper planar surface of each terrace in the northeastern part of the Edson-Hinton area. They are shown on the geologic map, Figure 3, in cross-section in Figure 10 and in Plates 3, 4 and 6. The range in elevation of the upper planar surface of the terraces and the physiographic unit in which each occurs is tabulated in Table 2.

Table 2 Pleistocene-Tertiary Terrace Levels

Terrace Level	Approximate Elevation Range (Feet)	Physiographic Unit
I	4800-4500	Mayberne Tableland
II	4400-4100	Mayberne Tableland
III	3950-3850	Edson Benchland
IV	3740-3500	Edson Benchland
V	3100-2900	Edson Lowland

The only well defined terraces are levels I and II which are surfaces of very low relief and which slope very gently to the north and northwest at 10 feet per mile in the

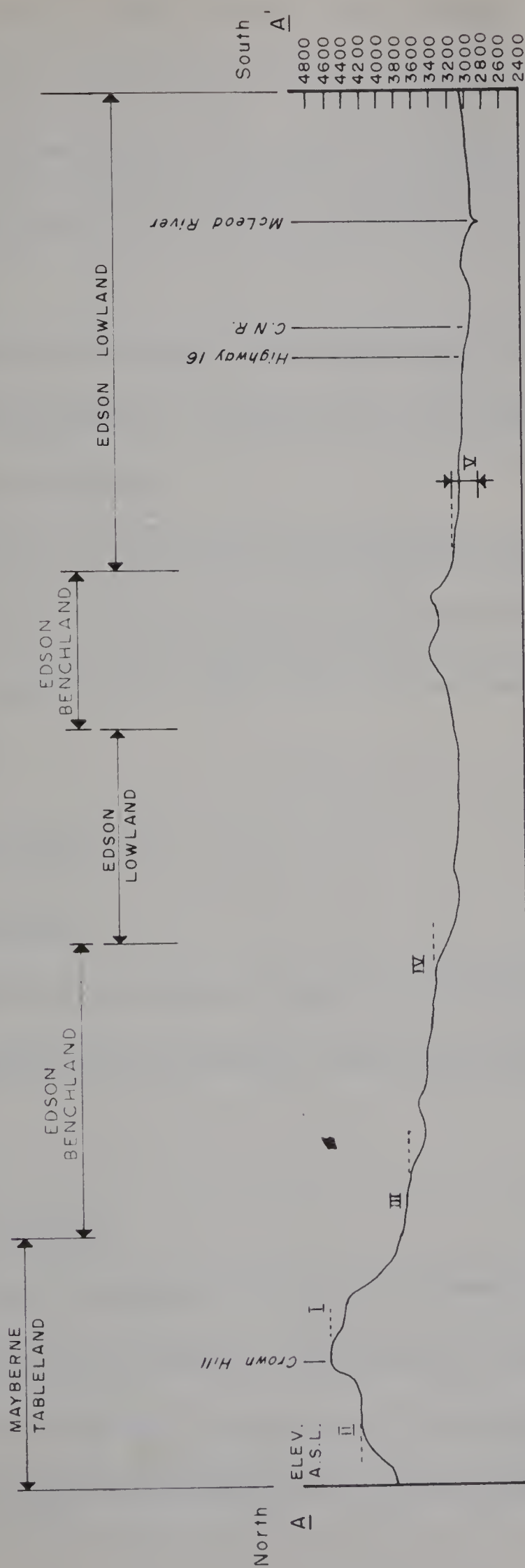
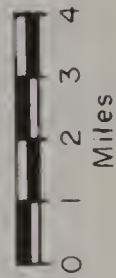


FIGURE 10

TOPOGRAPHIC CROSS-SECTION A-A' SHOWING
MAJOR PHYSIOGRAPHIC DIVISIONS AND PLEISTOCENE - TERTIARY
TERRACES I TO V

Vertical Scale 1"=2000'



area (Plates 4 and 6). In a very broad sense Levels I and II appear to correlate with the top of the Swan Hills 70 miles to the northeast. If this correlation is valid the terraces have a regional slope of 9 feet per mile to the northeast towards the Swan Hills. The same terraces are present in the western part of the area in the Athabasca Tableland and the Foothills, specifically on top of High Divide Ridge and Moberly Hill.

Terraces in the Edson Benchland are small in extent, ill-defined topographically and widely separated. The general level of the Edson Lowland is believed to represent a terrace (Plate 5).

Deposits of gravel below glacial deposits and overlying bedrock (Plate 5) have been found on all terraces except those located in the Edson Benchland. These deposits are described and the origin of the terraces is briefly considered in the section on stratigraphy.

Small-Scale Landforms

General Remarks

Small-scale landforms of glacial and nonglacial origin have been recognized in the physiographic units of the area. These include glacial landforms and nonglacial landforms.

Glacial Landforms

Glacial landforms of the area can be broadly divided into glacial depositional features, glacial erosional features, glaciolacustrine features, and glaciofluvial features. These landforms are mentioned in sections on the physiographic units and especially under the section on stratigraphy as allowed by the American Commission on Stratigraphic Nomenclature

(1961, p. 649), but the general distribution along with a short description of the glacial landforms is presented here.

(1) Glacial Depositional Features – Glacial depositional features are geomorphic units formed by the deposition of drift from the melting of dirty glacial ice and include hummocky dead-ice moraine, ground moraine, lobate end moraine and lateral moraine.

(a) Hummocky Dead-Ice Moraine (Bayrock, 1958, p. 11): Hummocky dead-ice moraine composed dominantly of till of Cordilleran and Continental source occupies only very minor parts of the area. The presence of hummocky dead-ice moraine is evidence of ice-disintegration.

(b) Ground Moraine (Bayrock and Hughes, 1962, p. 11): Ground moraine is extensively developed throughout the area, and is the dominant glacial depositional landform.

Besides the usual, a notable feature of the ground moraine associated with most of the Cordilleran tills of the area is a geomorphic feature referred to as "circles" in this report. They are circular in plan, the circle being marked by a band of lighter colored vegetation (Plate 7). They range in diameter from two hundred to one thousand feet, and they are flat, continuous with adjacent landforms and composed of till. These "circles" have been detected on flat ground and also on sloping ground, and may occur singularly or in groups of two or more in areas of ground moraine or in areas dominated by drumlins and flutings. The "circles" can easily be detected on aerial photographs but their origin is unknown.

The "circles" have been studied by P. Gimbarzevsky (personal communication) who has offered two possible explanations. The first idea is that the circles mark

the limits of spot fires caused by lightning strikes and subsequently put out by rain. Support for this idea is that the vegetation within the circles examined is slightly younger than the surrounding vegetation. The alternative idea offered by Gimbarzevsky is that the circles are a reflection of a textural difference in the till which presumably originated at the time of deposition during disintegration of the glacier. It is the opinion of Gimbarzevsky that the circles could not have originated organically, that is, by some disease of the vegetation, since the circles are too regular.

(c) Lobate End Moraine and Lateral Moraine: The two terms lobate end moraine and lateral moraine belong to a large group of drift forms referred to as end moraine (Flint, 1957, p. 131). Lobate end moraine and lateral moraine are common features in the area and are distinguished simply as till ridges on the geologic maps and described in detail for each map unit under the section on stratigraphy. Flint's general explanation for this type of drift is that it is a "ridgelike accumulation of drift built along any part of the margin of a glacier" (Flint, 1957, p. 131), however, the till ridges which occur as lobate end moraine and lateral moraine shown in Figures 2 and 3 probably formed during disintegration of the glacier by processes similar to those outlined by Gravenor (1955) and Gravenor and Kupsch (1959) during large-scale stagnation, since disintegration features, notably hummocky dead-ice moraine, are associated with these landforms.

(2) Glacial Erosional Features - Glacial erosional features are landforms which have been formed dominantly by erosional action of glaciers. These features include flutings and drumlins making up fluted or drumlinized plains or surfaces. Drumlins may have been formed from a variety of processes (Gravenor, 1953) but since the present writer

has not studied these features in detail, their inclusion under the heading of glacial erosional features is arbitrary.

Plains upon which flutings and drumlins have been developed occupy a large part of the Athabasca Benchland and Pembina-McLeod Benchland, and are related mainly to Cordilleran ice advances. Most of these features are composed of a thin layer of till which overlies bedrock, but at some localities, especially in the Athabasca Benchland, these landforms are composed mainly of till. Local relief in the vicinity of drumlins may be in the order of 100 feet but is commonly about 30 feet.

(3) Glaciolacustrine Features - Included in this topic are glacial lake basins. The largest glacial lake basin the area is centered on the town of Edson. The basin surface in general is irregular since it is interrupted in many places by prominent near-surface bedrock hills, drumlins, and flutings. In the northwest part of the area a narrow linear glacial lake basin formed in the valley of Oldman Creek upon melting of glacial ice in this part of the area. The geomorphic expression of deltaic deposits which are associated with lacustrine basins is discussed in the section on the Marlboro delta.

(4) Glaciofluvial Features - Glaciofluvial features of ice-contact origin include esker and esker complexes, kame and kame moraine, ice-marginal meltwater channels and pitted outwash; those of non-ice-contact origin include outwash terraces and outwash plains.

(a) Esker and Esker Complexes - Numerous narrow, sinuous ridges of sand and gravel occur in the area associated mainly with Cordilleran tills. Eskers ranging in length from a few hundred feet to three miles long and from ten

feet to fifty feet in height are characteristic of the fluted plain in the southern part of the area. Eskers associated with Continental tills in the area are extremely rare.

Esker complexes are composed of two or more eskers of which there are two striking examples in the area. One is located in the vicinity of Emerson Lakes (Sec. 6, Tp. 55, R. 22 W5). The Emerson Lakes esker complex consists of three to six eskers composed mainly of pebble to cobble size gravel. In over-all length the esker complex is over three miles long and one-half mile wide.

The other prominent esker complex is located north of the Athabasca River in Sec. 9, Tp. 54, R. 22 W5. This esker complex forms part of the terminal moraine of a Cordilleran glacier (see page 102) and is composed of one large esker over one mile long together with several smaller eskers with associated moulin kames. The elevation of this esker complex is approximately 3,350 feet.

(b) Kame and Kame Moraine - Isolated kames, probably moulin kames, composed mainly of sand are scattered throughout the area but are associated almost entirely with Cordilleran till. A spectacular example of the complex internal structure present in some kames is shown in Plate 8; this moulin kame occurs on the Athabasca Tableland.

Kame moraine, composed of a group of kames, notably occurs in three locations. One locality is in Tp. 56, R. 24, where the kames consist mainly of poorly sorted bouldery gravel containing lithologies of Cordilleran and Continental source. This kame moraine represents part of the terminal moraine of a Cordilleran glacier which was probably in contact with the Continental ice.

In Secs. 5,6 and 7, Tp. 51, R. 25 in the vicinity of Maskuta Creek, a kame moraine occurs which represents a stage in the retreat of a Cordilleran glacier. The moraine is composed of thick sand and gravel deposits, but the surface of the deposit exhibits shallow pits several hundred feet in diameter marking the positions of former blocks of ice. Small eskers also occur in the kame moraine on the north side of the Athabasca River valley.

The Maskuta Creek kame moraine is particularly significant because the valley train which was deposited downstream to the east now comprises the uppermost outwash terrace upon which the town of Hinton and the Canadian National Railway are built. This kame moraine also helped block the drainage from Maskuta Creek valley, forming the glaciolacustrine deposits which are exposed in that general area.

(c) Ice-marginal Meltwater Channels - Prominent ice-marginal channels which have been eroded in drift and bedrock occur mainly in the southeastern part of the map-area; the best example is the Pembina River. In the northeastern part of the area the most prominent ice-marginal meltwater channel is now occupied by Sundance Creek.

(d) Pitted Outwash - Classic examples of pitted outwash occur at several places in the Jarvis Lake Valley. Pits representing vanished blocks of ice, are up to 100 feet deep; pits 50 to 60 feet deep are commonplace. Pitted outwash is composed mainly of gravel ranging from pebble to cobble size, but inclusions of till and beds of sand, silt and clay are common (Plate 9). The pitted outwash in the Jarvis Lake Valley was deposited during the melting of a Cordilleran glacier which extended to the north as far as the Wildhay River.

(e) Outwash Terraces - Outwash terraces are widespread in the area. They occur along the flanks of the major stream valleys as shown on the geologic maps (Figures 2 and 3). The most prominent outwash terraces are located in the vicinity of Hinton and are named the Hinton terraces and discussed in detail in the section on stratigraphy of this report (Plates 10 and 11).

(f) Outwash Plains - The largest outwash plain in the Edson-Hinton area is located in the Wildhay Benchland in the vicinity of Tp. 57, R. 22. This landform is characterized by low relief and is composed mainly of sand. Parabolic dunes and extensive tracts of muskeg are common features of the surface of the plain. Another outwash plain of large dimension is located in Tp. 50, R. 16; this one is mainly sand and gravel forming a surface of low relief.

Nonglacial Landforms

The main small-scale landforms of nonglacial origin in the area are sand dunes and present stream valleys. Sand dunes are mainly parabolic in form; small blowouts are present in association with some dunes. Arrows representing the inferred wind direction during dune formations are given for all dune fields in Figures 2 and 3.

Present major stream valleys are rarely over 100 feet deep. Also, the valleys are narrow compared to downstream counterparts on the plains northeast of the area.

BEDROCK GEOLOGY

Introduction

The general distribution of rock types in age from Tertiary to Pre-cambrian is shown in the regional bedrock geology map of the area (Figure 9). This map was compiled from the files of the Research Council of Alberta, Campbell (1966), Price and Mountjoy (1966), and Price (1967). The stratigraphy and lithology are described only in a general manner in the text but a more detailed account of the lithologies and thicknesses of the bedrock groups and formations which were exposed to glacial erosion is given in Table 3. The general structure of the area has been described under the section on physiography and is broadly included in this section in order to simplify description. Reference to Figure 5 should be made for the location of various features referred to in the following pages.

Bedrock Lithology and Stratigraphy

The eastern part of the Edson-Hinton area is underlain by the Paskapoo Formation which consists of weakly consolidated sandstone, siltstone and shale of Paleocene age (McCrossan and Glaister, 1964). Some conglomerates are present in which the pebbles are predominantly metaquartzite, sandstone and chert. Thin beds of Tableland gravel overlie the Paleocene sediments in areas of tablelands.

Rocks forming the foothills in the vicinity of Hinton are composed of a thick sequence of clastic rocks which belong mainly to the Brazeau Formation of Late Cretaceous age. Farther west are the Front Ranges underlain by carbonate, argillaceous and arenaceous rocks of Devonian to Permian age (Mountjoy, 1961, 1962).

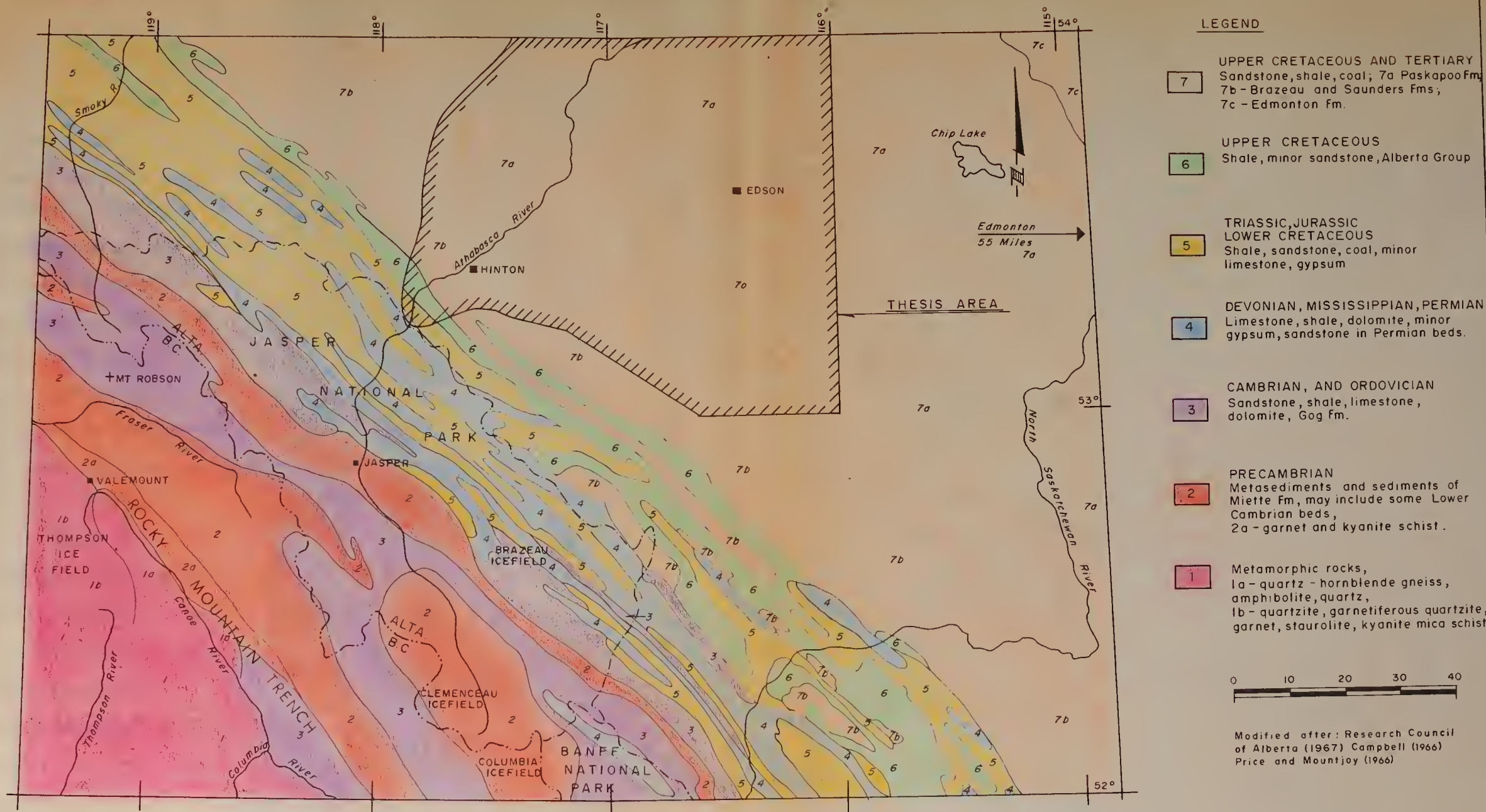


FIGURE 9

REGIONAL BEDROCK GEOLOGY
ADJACENT TO EDSON-HINTON AREA

The Main Ranges (Mountjoy, 1962), which extend from Jasper townsite west to the Continental Divide, are formed of an upper thick sequence of carbonate rocks (Upper and Middle Cambrian), and middle sequence of orthoquartzites (Lower Cambrian and older-Gog Group), and a lower sequence of recessive dark grey and greenish grey shales and argillites with resistant units of poorly sorted sandstones which range in composition from feldspathic sandstones to orthoquartzites (Precambrian-Miette Group). In the vicinity of Yellowhead Pass, the upper parts of the north-westerly trending mountains are composed of Gog sandstones whereas the valleys are generally underlain by the more recessive strata of the Miette Group. Younger rocks occur near Mount Robson to the northwest of Yellowhead Pass, and near Fortress Lake to the southeast. Some of the Miette rocks exhibit low-grade metamorphism of the greenschist facies with the development of sericite and some albite. No metamorphic rocks above low metamorphic grade are known to occur in any of these areas.

The area between the Continental Divide and the Rocky Mountain Trench (Figure 5) is being mapped by the Geological Survey of Canada (Campbell, 1966; Price and Mountjoy, 1966; Price, 1967). Sufficient information is available to outline the general distribution of the major rock types. The Selwyn Range is underlain by rocks of the Miette Group, which near the Rocky Mountain Trench are complexly deformed and consist of schist containing small garnets. In a few areas, schist contains kyanite (see Price and Mountjoy, 1966, Fig. 3, p. 120, for position of metamorphic isograds). One small area southeast of Valemount (Figure 9) is underlain by hornblende gneiss.

West of the Rocky Mountain Trench, a greater variety of metamorphic rocks is present (Campbell, 1966). The Premier Range southwest of Valemount is underlain pre-

dominantly by garnet schist with local areas of garnet-kyanite schist. The Cariboo Mountains consist largely of garnet schist. A few small areas are underlain by kyanite-staurolite-garnet schist, marble and biotitic granite. The northern end of the Monashee Mountains comprises a triangular area between the North Thompson and Canoe rivers and consists of quartz-hornblende gneiss, except for a relatively narrow area of kyanite-garnet schist northwest of Boat Encampment.

The general lithology of bedrock formations which were exposed to glacial erosion in west central Alberta and adjacent British Columbia is given in the following table.

Table 3 - Bedrock Lithologies

AGE AND STRATIGRAPHIC UNIT	GENERAL LITHOLOGY
Tertiary - (mainly Paskapoo Fm., Entrance conglomerate, and Tableland gravel)	Sandstone, chert conglomerate, shale, coal, some thin beds of gravel composed mainly of metaquartzite cobbles. 4,000 feet $\pm$.
Upper Cretaceous - Brazeau Fm. and Alberta Group:	Sandstone, shale, conglomerate, marine and non-marine. 7,500 feet $\pm$.
Lower Cretaceous - Blairmore Group:	Shale, sandstone, conglomerate, coal; mainly non-marine. 3,000 feet $\pm$.
Jurassic - Fernie Group:	Black and dark grey shale, sandstone, concretionary. 700 to 900 feet.
Triassic - Whitehorse and Sulphur Mountain Fm.:	Carbonate, light grey breccia, red mudstone, gypsum, siltstone, mudstone. 600 to 1,000 feet.

Permian and/or Pennsylvanian - Rocky Mountain Fm.:	Massive grey chert, cherty brown sandstone. 0 to 200 feet.
Mississippian - Rundle Group and Banff Fm.:	Brown dolomite, dark grey limestone, chert, calcareous shale. 2,000 feet $\pm$.
Devonian - Palliser Fm. and Fairholme Group:	Dark grey and brown limestone, black shale, sandstone, chert, fossiliferous limestone. 2,500 feet $\pm$.
Lower Ordovician:	Limestone, intraformational conglomerate. 0-1,500 feet.
Middle and Upper Cambrian:	Limestone, red and black shale, siltstone. 4,000 - 6,500 feet.
Lower Cambrian - Gog Group:	Orthoquartzite, light grey, purple, red, quartzose and feldspathic, banded and cross-bedded, pebbly. 4,000 feet $\pm$.
Precambrian - Miette Group:	Shale, phyllite, sandstone and conglomeratic sandstone; carbonates. 5,500 feet $\pm$.
Precambrian - Shuswap Metamorphic Complex:	Quartz-hornblende gneiss, amphibolite, quartz, metaquartzite, garnetiferous quartzite; garnet, staurolite, kyanite, mica schists. 5,000 feet $\pm$.

STRATIGRAPHY OF SURFICIAL DEPOSITS

Introduction

The principal surficial deposits of the Edson-Hinton area consist of gravel that predates glacial deposits, till, glaciofluvial sediments, glaciolacustrine and interstadial sediments, and nonglacial Recent deposits. These deposits are described from oldest to youngest where possible and arranged in order to conform with the legend of the geologic maps (Figure 2 and 3).

A complete stratigraphic sequence is not exposed in the area, nor are there radiometric ages available for any of the deposits except for three nonglacial Recent deposits. Localities referred to in the text are given on the location map (Figure II) and a total of twenty-one detailed stratigraphic sections is included in Appendix C. Results of laboratory investigations described in Appendix A are given in this section where pertinent.

Due to the inherent difficulty in systematically defining and discussing the stratigraphy of the many surficial units of variable lithology and geomorphology in this reconnaissance study, and in order to conform to the geologic map legend of Figures 2 and 3, the discussion of stratigraphic units is divided into two parts. The first part describes rock stratigraphic units which are presented according to standard procedure; the second part describes "other stratigraphic units" and their presentation is a slight departure from the rigid form adhered to in the section on rock stratigraphic units.

Rock Stratigraphic Units

General Remarks

Surficial Units which can be distinguished and delimited on the bases of lithology, stratigraphy, geomorphology and areal extent include Pleistocene - Tertiary gravels and Pleistocene tills.

Pleistocene - Tertiary Gravels

Three gravel units which predate the glacial deposits in the area have been separated from other deposits on the basis of geomorphology, stratigraphy and mineralogy. Two of the gravel units are found on the Pleistocene-Tertiary terraces and are called from older to younger: Tableland gravel, Lowland gravel. The third and youngest gravel unit is called the Buried Valley gravel and occurs near or at the bottom of buried valleys.

Tableland Gravel

(1) Definition and Lithology - The Tableland gravel is briefly mentioned on page 16 and described as gravel occupying the area of tablelands and composed mainly of rounded metaquartzite cobbles and boulders (72 per cent) with a lesser amount of feldspathic and quartzose sandstones (sample No. 266). The matrix is fine to medium-grained quartz but considerable fine-grained muscovite, clay and silt are present. Two outcrops have been examined on the Mayberne Tableland (Figure 7)

associated with the Pleistocene-Tertiary terrace II (Plate 6, Figure 10) where a minimum of seven feet of gravel is exposed. Poor exposures also occur in the Vicinity of the Obed Fire Tower and on High Divide Ridge in the Athabasca Tableland. The gravel appears to be mainly in the form of elongate discontinuous lenses but it is not known whether this reflects initial deposition or subsequent erosion.

(2) Stratigraphic Relationships - Till overlies the Tableland gravel except at the site of Mayberne Fire Tower (elevation 4,753 feet, Figure 13) where till has not been identified and the gravel forms the surface of Pleistocene-Tertiary terrace of Level I (Figure 10). The lower contact of the Tableland gravels has not been observed, but it is inferred that the unit is underlain by the Paskapoo Formation of Paleocene age.

(3) Origin - Metaquartzites predominate in the gravels and to the writer's knowledge are not known to crop out east of the Rocky Mountain Trench. The heavy mineral suite of the Tableland gravel is very distinctive (see Table 4, locality No. 266). Staurolite, rutile and kyanite are very common in the gravel compared to the tills of the area, also, garnet is not as abundant in the gravels as it is in the tills. These features, together with the roundness of the cobbles and boulders, which indicates extensive transportation, suggest a provenance composed of kyanite and staurolite schist terrain located west of the Rocky Mountains. Some cobbles, however, are similar to orthoquartzites and feldspathic orthoquartzites of the Gog and Miette Groups of the Rocky Mountains (Table 5, Locality No. 266).

Lowland Gravel

(1) Definition and Lithology – Widely separated deposits of gravel underlie till and overlie bedrock at numerous localities in the Edson Lowland. These gravel deposits are referred to as Lowland gravel since they have been recognized only in the Edson Lowland. The type locality is in the SE 1/4 Sec. 26, Tp. 54, R. 16, W5 (Section No. 263, Unit No. 3) where the gravel is three feet thick; in other places, the gravel is as much as five feet thick.

The Lowland gravel at the type locality consists of poorly sorted pebbly gravel. Pebbles have a mode of one inch, but the gravel contains cobbles up to six inches in diameter. The matrix is mainly fine to medium-grained quartz sand with small amounts of clay and silt; pebbles are subrounded to subangular and composed mainly of metaquartzite, chert, lithic sandstone and other quartzites (Appendix A, Table 5). Heavy minerals are composed of a Cordilleran suite (Appendix A, Table 4) including abundant zircon, garnet, and epidote similar to the Cordilleran tills of the area (Figure 12-C).

(2) Stratigraphic Relationships – Lowland gravel underlies the Edson till and overlies bedrock of the Paskapoo Formation where it has been examined (Plate 5). The occurrences of the gravel are unpredictable since they are preserved in scattered patches; however, the main localities are near bedrock highs where till is very thin. In general the gravels are found at elevations between 2900 and 3100 feet (Figure 10) in the Edson Lowland. The Lowland gravel predates known glacial deposits of the area.

(3) Origin - The Lowland gravel is believed to represent the deposits of easterly flowing streams, possibly glacial in origin, during erosion and development of the Edson Lowland.

Buried Valley Gravel

(1) Definition - Buried valleys are valleys which have been formed mainly by stream erosion and have been later infilled with glacial or other material. Some valleys are completely filled, others are only partly filled and form visible depressions in the modern topography. Gravel that occurs near or at the bottom of the buried valleys is called Buried Valley gravel in this study. Buried Valley gravel may occur associated with any landform. No attempt has been made to distinguish between different ages of Buried Valley gravel but this gravel does not necessarily predate glacial events since interglacial Buried Valleys are known (Figure 8).

Some Buried Valley gravel deposits have been studied in the subsurface in the vicinity of the town of Edson (Gabert and Roed, in press). However, only one outcrop of the Buried Valley gravel is present in the area (Section No. 278, Unit No. 4); this is the type locality and it occurs on a south facing bank of the Edson River in SE 1/4 Sec. 16, Tp. 54, R. 16, W5 where the gravel overlies the Paskapoo Formation and is overlain by the Edson till. The gravel here is six to eight feet thick and as determined in the subsurface it occurs at elevations of 2800 to 2900 feet.

(2) Lithology - The Buried Valley gravel consists of pebbly gravel containing 80 per cent pebbles. The pebbles have a mode of two inches in diameter but range up to four inches in diameter. The matrix is fine to coarse-grained lithic sand. Pebbles are mainly subrounded and are composed of orthoquartzites, feldspathic orthoquartzites, metaquartzites, limestone, and siltstone and lithic sandstone (Table 5, Locality No. 278-4). Heavy minerals are typical of a Cordilleran source (Table 2, Locality No. 278-4). Some of the pebbles are imbricated indicating a current flow from the northwest. From the subsurface investigation in the vicinity of the town of Edson, the gravel is known to be sporadic in occurrence and is mainly in the form of large discontinuous lenses.

(3) Origin - The deposit of Buried Valley gravel at the type section originated by deposition from fluvial or glacial streams prior to the first advance of Continental ice in the area. Other Buried Valley gravels may have a different origin.

Pleistocene Tills

General Remarks

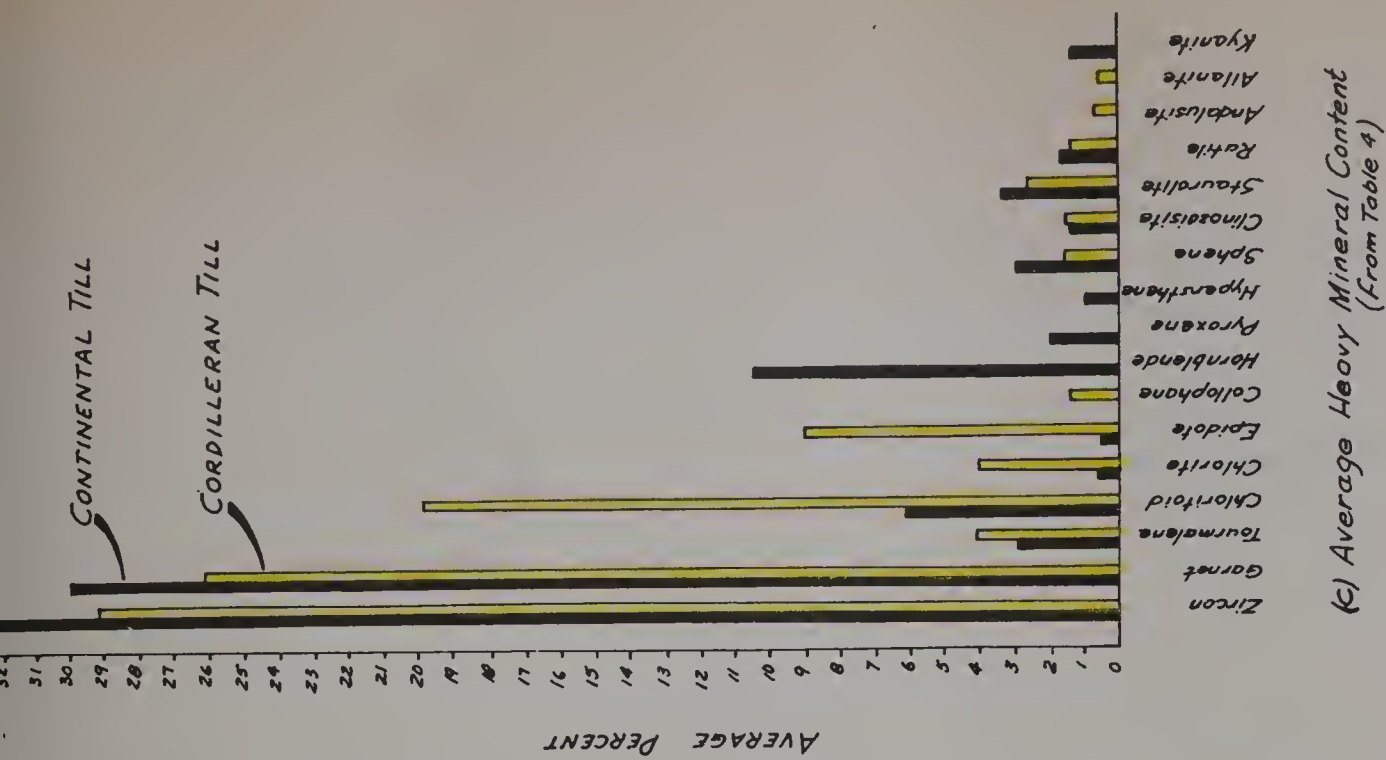
Till is the most widespread glacial deposit in the area. Seven tills have been identified and are interpreted to indicate at least three and possibly four glacial advances. Fragmentary evidence for a fifth glacial advance or an "Early" Cordilleran advance is also present but the evidence does not constitute a rock stratigraphic unit. The tills are: 1) Marsh Creek till; 2) Edson till; 3) Mayberne till; 4) Marlboro till; 5) Raven Creek till; 6) Obed till; 7) Drystone Creek till.

Diagrams summarizing the principal differences in the laboratory analyses of Continental and Cordilleran till are given in Figures 12 and 13. The term Cordilleran source employed throughout the text refers to rock types derived mainly from the Rocky Mountains since the only rocks derived from west of the Rocky Mountains are metaquartzites and the metamorphic rocks referred to above. The terms, Continental and/or Canadian Shield source, refer to rock types or glaciers which have originated in the Canadian Shield region.

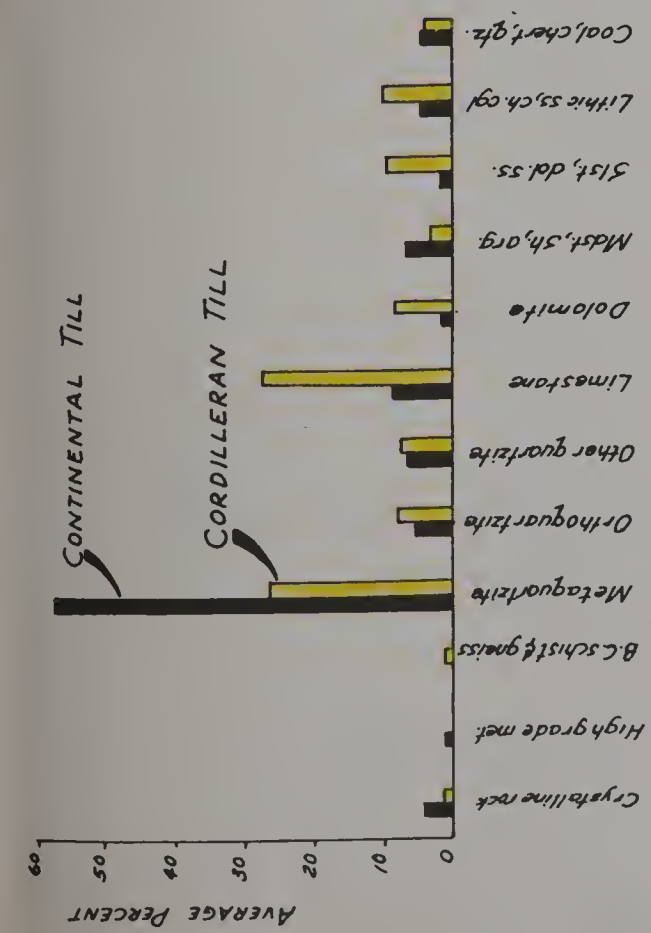
A general table showing the relative age of the various till units and their respective sources is give in Table 8 (the evidence for placing these tills in the positions set out below is given on the following pages). This table is included here in order to simplify discussions in the text; Table 6 is a more detailed form of this table. A diagrammatic cross-section illustrating the stratigraphic relationships of the principal till rock stratigraphic units and other surficial sediments in the area is given in Figure 14 (in pocket).

Table 8 - Relative Age of Till Units in the Edson-Hinton Area.

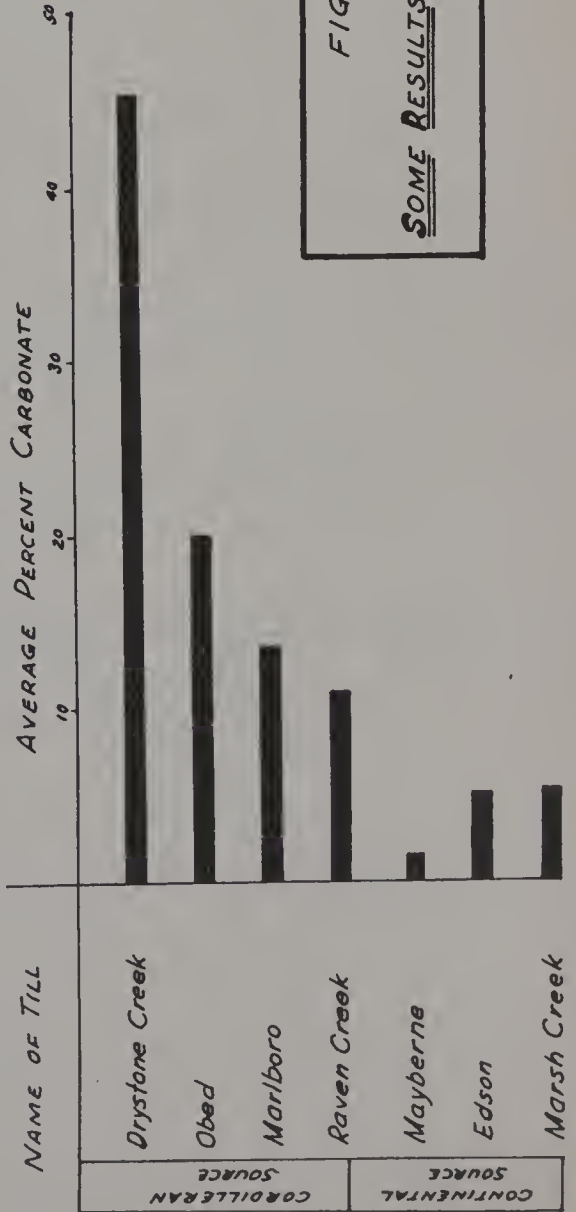
RELATIVE AGE	GLACIAL ADVANCE	NAME OF TILL		
		CORDILLERAN SOURCE	MIXED SOURCE	CONTINENTAL SOURCE
Youngest	5	Drystone Creek Till	Mixed Till	Not present
	4	Obed Till		Not present
	3	Marlboro and Raven Creek Tills		Edson and Mayberne Tills
	2			Marsh Creek Till
Oldest	1	Evidence of "Early" Cordilleran Advance		



(c) Average Heavy Mineral Content (From Table 4)



(a) Average Pebble Lithology (from Table 5)



(b) Average Carbonate Content (from Table 13)

FIGURE 12
SOME RESULTS OF TILL ANALYSES

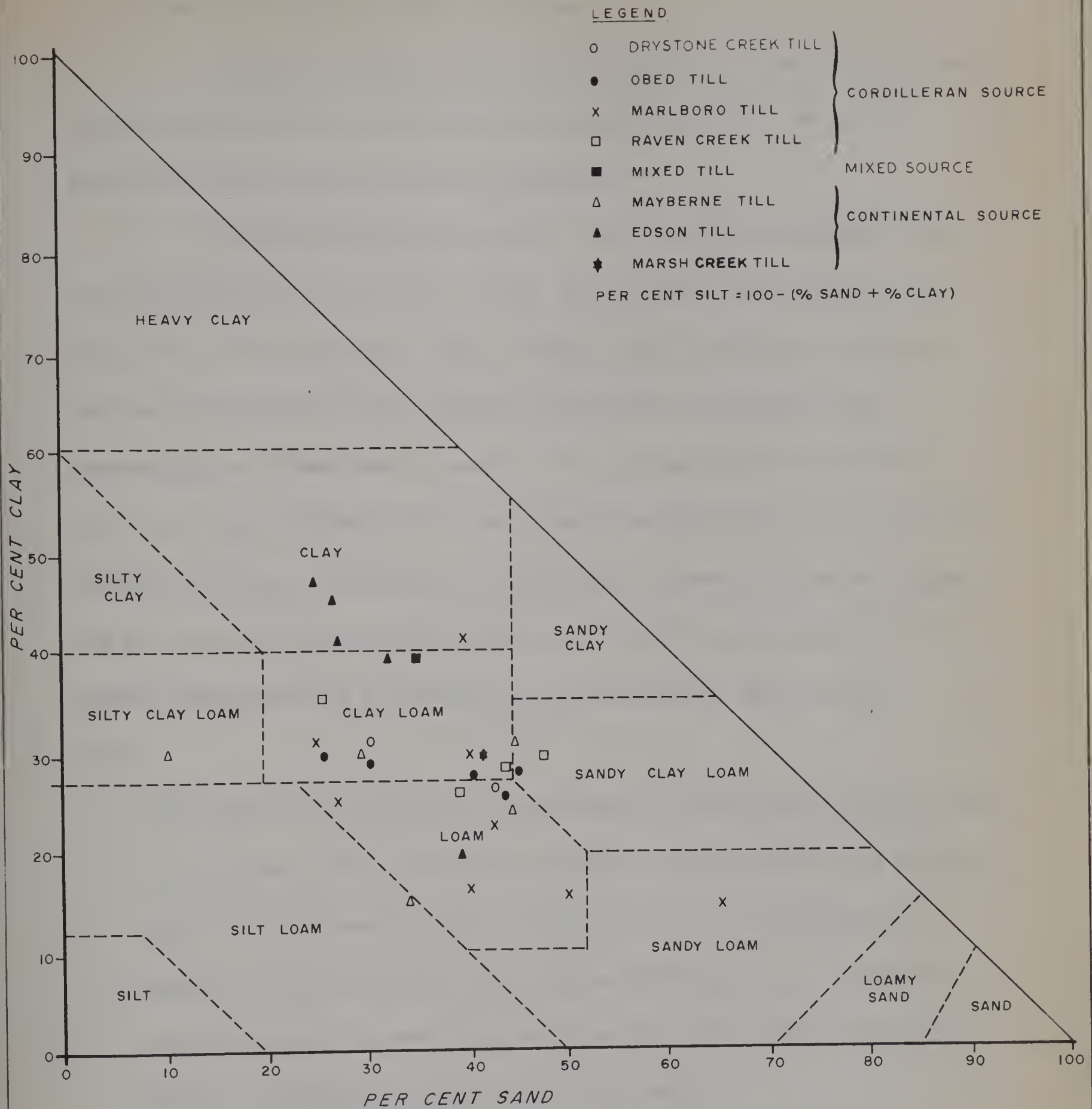


FIGURE 13

SOIL TEXTURE TRIANGLE OF TILLS IN THE EDSON-HINTON AREA

Evidence of "Early" Cordilleran Advance

Although the evidence of an "Early" Cordilleran advance does not form a rock-stratigraphic unit and should not be included here, there is not a better place in the text to discuss this than in this section.

In the Canadian Rocky Mountains "Early" Cordilleran glaciations have been described by Horberg (1954, p. 1102), Tharin (1960), Stalker (1963, p. 41), Rutter (1965, 1966) and Wagner (1966). Several "Early" Cordilleran glaciations have been described by Richmond (1965) in the Central and Northern Rocky Mountains of the United States of America. It is only reasonable to suspect that one or more early Cordilleran glaciations affected the Edson-Hinton area, but direct evidence is lacking. Fragmentary pieces of indirect evidence do, however, suggest that the area was considerably affected by ice of Cordilleran source prior to the earliest known advance of Continental ice. This evidence is briefly outlined below:

1. The presence of an orthoquartzite erratic similar to rock types of the Gog Group in the Mayberne till at an elevation of 4000 feet on the west flank of Mayberne Upland (Figure 5) several miles east of the known limit of Cordilleran ice suggests an early Cordilleran advance of considerable extent. Alternatively, southward moving Continental ice may have carried the erratic southward from the low-lying Athabasca River valley to this locality.
2. Erratics of the Gog Group occur within till of Continental source well east of the known limit of Cordilleran ice southeast of Edson (Figure 5). All of the flutings and drumlins in the vicinity and the composition of the till record the

presence of Continental ice. These erratics, therefore, suggest a Cordilleran glacier advance of considerable extent prior to the advance of Continental ice. Alternatively, the erratics may have been deposited in a mixed zone of Continental and Cordilleran ice.

3. Erratics of Canadian Shield origin are absent in an area along the Athabasca Benchland (Figure 5). This suggests that a Cordilleran valley glacier occupied this part of the area preventing the transportation of Canadian Shield erratics during the first advance of Continental ice (Marsh Creek advance). It could also be argued that Canadian Shield erratics simply have not been discovered in this area.
4. Jarvis Lake Valley (Figure 7) is a conspicuous incongruent topographic feature of the area and could only have been formed as a result of some special circumstance. The most logical explanation is to consider that the incipient development of the valley was the result of a northward diversion of drainage which would have normally flowed down the Athabasca Valley. This diversion may have been caused by the presence of a Cordilleran valley glacier in the Athabasca River valley. Field mapping has established that the Jarvis Lake Valley predates the Marlboro till and therefore may represent a feature developed during an early Cordilleran glaciation.

The above fragmentary evidence suggests that early Cordilleran glaciers may have invaded parts of the Edson-Hinton area. These glaciations may be of more than one age.

Marsh Creek Till

- (I) Definition and Lithology - The Marsh Creek till is named after Marsh Creek which

flows into the Oldman Creek in the northwestern part of the area. Only one exposure of the till is known and it is at the type section located in NW 1/4 Sec. 13, Tp. 55, R. 23, W5 on the south bank of Oldman Creek (Oldman Creek Section No. 271, Locality No. 271-3) where it is at least 35 feet thick.

Although this outcrop of Marsh Creek till is being actively eroded by the creek and is affected by extensive mud flows the stratigraphic position and general lithology of the till is not in doubt. It is medium grey in colour, dense, plastic, moderately stony, contains pebbles with a mode of one-half inch in diameter, but with cobbles up to 4 inches in diameter. The texture of the matrix is a clay loam. The pebbles (Table 5, Sample No. 271-3) are dominantly metaquartzites but up to 12 per cent crystalline igneous rocks of Canadian Shield origin are present. The heavy mineral suite (Table 4, Sample No. 271-3) is similar to that of Continental tills (Figure 12) in the area. The carbonate content is 5 per cent.

(2) Contacts - The lower contact was not observed. The upper contact with overlying outwash gravel is sharp and may be erosional. This gravel is referred to as Marsh Creek outwash and contains numerous pebbles of crystalline rocks derived from the Canadian Shield and a heavy mineral suite of Continental source. The Marsh Creek outwash gravel is in turn overlain by Marlboro till.

(3) Origin - Marsh Creek till is lithologically similar to Continental tills of the area, so it is considered to have been deposited by Continental ice. The till records the oldest known advance of a Continental glacier into the area. The limit of this advance is not known but it has been inferred from the distribution of Canadian Shield erratics (Figure 5). The absence of Canadian Shield erratics to the west of the line shown

in Figure 5 may be explained by inferring that eastward moving Cordilleran ice prevented further westward advance of the Continental ice. Although approximate, this line cuts across 1000 feet of topography decreasing in altitude toward the north, as drawn in Figure 5. From this, the line is inferred to represent an ice-contact zone, which indicates the presence of Cordilleran ice to the west when the Canadian Shield erratics of the Marsh Creek till were deposited.

Edson Till

(1) Definition - A large part of the Edson Lowland is covered with Edson till. The till also occurs in parts of the Wildhay and Athabasca Benchlands. The till is named after the town of Edson but the type section is located in SW 1/4 Sec. 21, Tp. 54, R. 15, W5 where 10.5 feet of Edson till is exposed in a cutbank of the McLeod River valley and along the road (Rosevear Section No. 265, Appendix C, Figure 11). The Edson till ranges in thickness from a few inches where bedrock is close to the surface to over one hundred feet in buried valleys of the Edson Lowland (Gabert and Roed, in press). The average thickness is approximately 20 feet. The sample (No. 265-3) from this till on evidence of field mapping is considered typical of the till of Continental source and has been established as the lithologic standard of Continental till in the area.

(2) Lithology - The Edson till is dense, plastic when moist, medium to dark olive brown where oxidized and medium grey where unoxidized. It is stone poor to moderately stony, containing pebbles with a mode of one and one-half inches but with boulders up to fourteen inches in diameter. Pebbles consist of metaquartzites, sandstone and shale from local bedrock, and crystalline rocks of Canadian Shield origin, but limestones and orthoquartzites are not uncommon.

Crystalline rocks of the Canadian Shield are rare in Edson till in the vicinity and to the west of the town of Edson. This paucity of Canadian Shield erratics is not understood. It is even more pronounced near the contact with the Marlboro till since there are localities where these erratics have not been found despite repeated careful searches.

Texturally the Edson till is mainly a clay, but the till consists of clay loam and loam at some localities. The heavy mineral suite is considered to be typical of a Continental source (Table 4, sample No. 265-3). Carbonate content of three samples averages 5 per cent.

(3) Stratigraphic Relationships - At the type locality, the Edson till directly overlies bedrock of the Paskapoo Formation. It is known from test-hole information (Gabert and Roed, in press) that the till overlies Buried Valley gravel in the vicinity of Edson. The Edson River Section (Locality 278, Appendix C) exposes till similar to the Edson till which also overlies Buried Valley gravel. At this section, however, several layers of bedrock occur within the till and the stratigraphic relationships are not clear. There may be more than one till sheet at this locality.

Throughout the Edson Lowland, the Edson till commonly overlies thin discontinuous patches of Lowland gravel. The contact between the two units is irregular (Plate 8, Locality 263), and pockets of the gravel commonly occur in the lower part of the till.

Where the Edson till does not form the surface deposit it is overlain either by glaciolacustrine sediments (Plate 12), aeolian sand of the Edson and Rosevear dune fields, or muskeg. At some localities the upper contact with the glaciolacustrine sediments is marked by a thin layer of pebbles (Plates 13 and 14). The pebbles constitute a

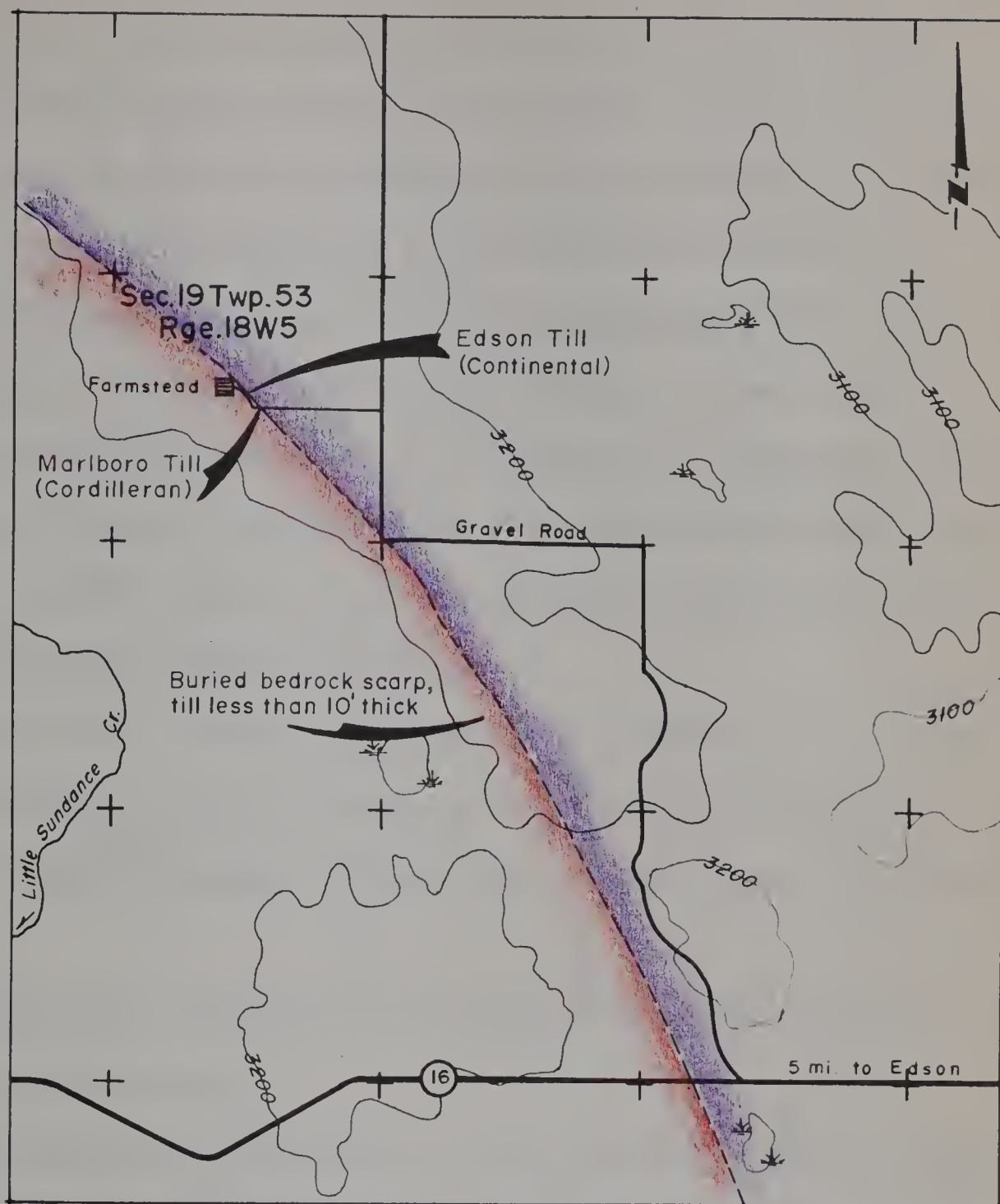
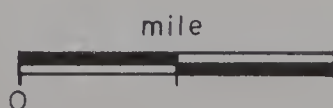


FIGURE 15

MAP SHOWING DETAILED LOCATION AND SETTING
OF CONTACT BETWEEN MARLBORO TILL
(Cordilleran Source) AND EDSON TILL
(Continental Source)

LEGEND

- Defined Geologic Contact Between Marlboro and Edson Tills
- - - Approximate Geologic Contact Between Marlboro and Edson Tills
- 3200 Topographic Contour - 100' Interval
- ⊗ Lake or Swamp



residual layer developed by erosion of the Edson till upon "transgression" of the Lake Edson water.

To the north the Edson till grades into the Mayberne till with increase in pebble content (Table 14, compare localities 214 and 249). The contact between the two tills is gradational and is generalized on the geologic map (Figure 3). The pebble increase is marked by the appearance in the Mayberne till of more meta-quartzite pebbles which have been derived from the Tableland gravel of Mayberne Tableland. However, in the Edson Lowland, some localities are known where an unusual number of metaquartzite pebbles occur in the Edson till. An example of this is on the south side of Highway 16 on the west side of the McLeod River bridge (Table 14, locality 285). It may be that the till has incorporated local patches of Lowland gravel or Buried Valley gravel at these localities.

Towards the south, the Edson till grades into the Mixed till. This contact is arbitrary, marked only by a general decrease in crystalline rocks of Canadian Shield source and a general increase in limestone and orthoquartzites of Rocky Mountain source.

Some stratigraphic relationships of the Edson till are diagrammatically presented in Figure 14 (in pocket).

Five and one-quarter miles west of the town of Edson, the Edson till passes abruptly into the Marlboro till (Figure 15). This contact zone is well exposed along a farm road and can be traversed during a short walk. On the east Edson till occurs (in which crystalline rocks of Canadian Shield origin have not been found) and to the west typical Marlboro till occurs with numerous striated limestone and quartzose sandstone erratics. The details of this contact are shown in Figure 15. This abrupt contact is also present to the northwest in Sec. 19, Tp. 54, R. 19, W5 but at an elevation nearly three hundred feet higher. Projection of this contact line between

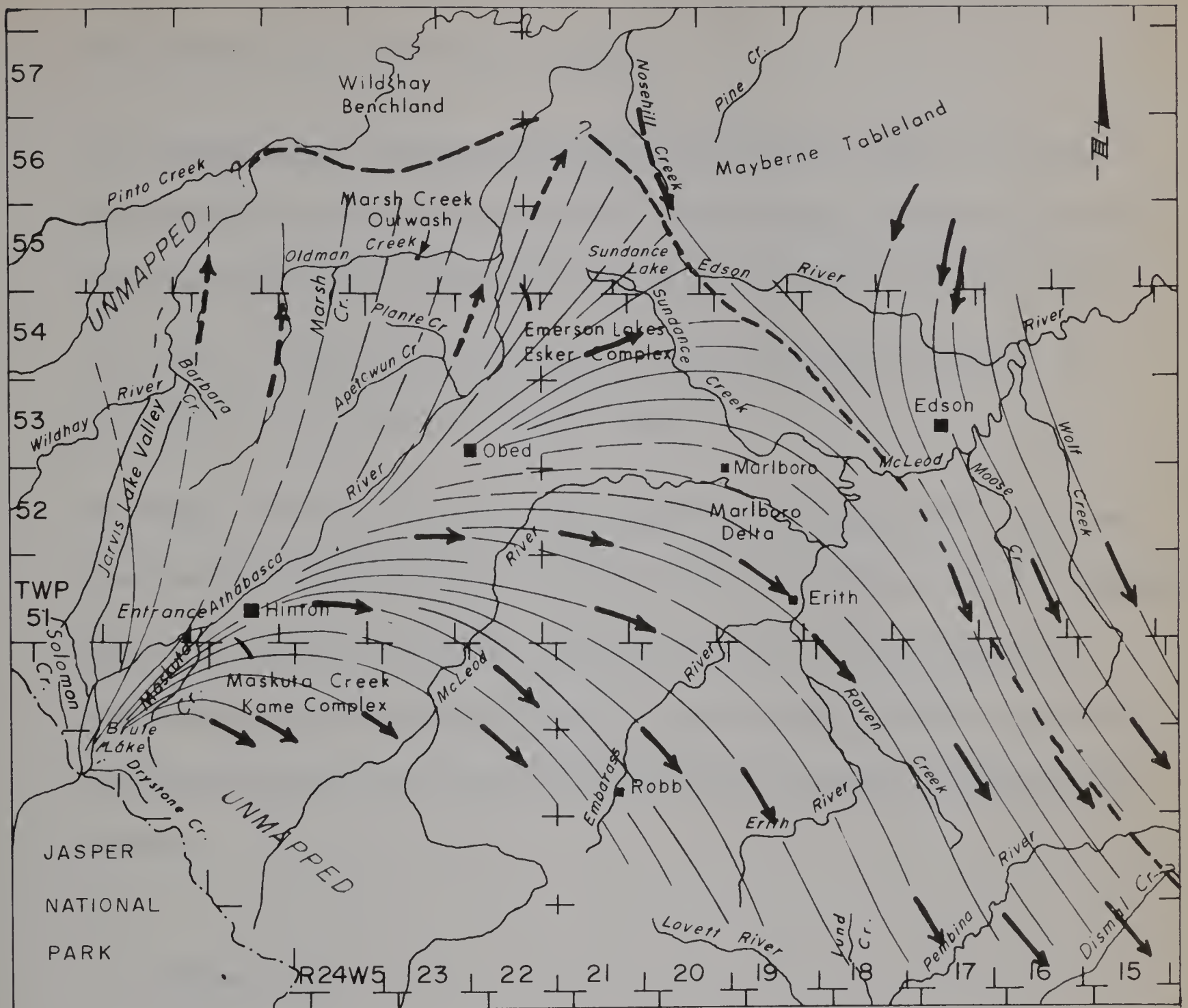


FIGURE 16

INFERRED ICE FLOW OF GLACIERS WHICH DEPOSITED MARLBORO AND RAVEN CREEK TILLS, EDSON, MAYBERNE AND MIXED TILLS.

the Edson and Marlboro tills to the north by routine field mapping indicates that the contact ascends nearly one thousand feet. This evidence demands that the glaciers which deposited the two tills were in contact.

(4) Geomorphology - Ground moraine (Bayrock and Hughes, 1962, p. 11) is the main geomorphic expression of the Edson till. A few drumlins and grooves are present; the northernmost drumlins record glacier movement to the southwest and the drumlins to the south of Highway 16 record glacier movement to the south or southeast. An interpretation of flow direction is given in Figure 16.

(5) Origin - The Edson till and its lateral equivalent the Mayberne till, record the latest Continental glacial advance in the area which was synchronous with the Cordilleran glacier that deposited the Marlboro and Raven Creek tills. The southwestern or western advance of this Continental glacier was prevented by Cordilleran ice, which forced the Continental ice to flow to the southeast nearly parallel to the trend of the Foothills.

Mayberne Till

(1) Definition - Mayberne till forms the principal surficial deposit of the Mayberne Tableland. The type locality is located in a fill pit alongside a road in SE 1/4 Sec. 27, Tp. 57, R. 17, W5 (Sample No. 249). The till is eight feet thick at the type locality, but it ranges in thickness from zero at high elevations to over twenty feet thick in some valleys such as Pine and Beaver Creek valleys. The average thickness over the tableland is probably less than five feet. The name Mayberne is taken from Mayberne Fire Tower (SE 1/4 Sec. 30, Tp. 56, R. 18, W5). Although the till is not exposed at this locality,

the name was chosen because of a scarcity of geographic names in the area.

(2) Lithology - The till is light grey brown to dark brown, slightly plastic when moist, moderately stony to very stony with a pebble mode of one and one half inches diameter, but the till contains boulders up to six feet across. It is classified as a loam and clay loam in texture. The pebbles are dominantly rounded metaquartzites (Plate 15 and Figure 17) but include a low percentage of crystalline rocks of Canadian Shield origin (Table 5). It is very difficult to find any evidence of crystalline rocks at some localities; this is particularly true in parts of the Edson Benchland south of Crown Hill (Figure 11). Similar problems were encountered by Mathews in the Fort St. John area of British Columbia (1963, p. 8) "...and in a few places foreign rocks are so rare that the till can only with difficulty be distinguished from residual soil." and also by St. Onge (1967b) in the Iosegun area north of the present area. At other localities large erratics of Canadian Shield origin are very obvious. A noteworthy example of this is on the east side of the road at the top of Crown Hill (altitude 4,400 feet) on the surface of Pleistocene-Tertiary terrace level II (Figure 3) where a large, angular block of hornblende gneiss occurs. The heavy mineral suite of the Mayberne till (Table 4, Sample No. 249) is similar to other Continental tills of the area. The carbonate content is very low, the average being 2 per cent for three samples.

(3) Stratigraphic Relationships - The Mayberne till overlies Tableland gravel, and shale and sandstone of the Paskapoo Formation. The contact with the Paskapoo Formation has not been observed. The contact with the gravel is generally quite sharp but, since the till is so stony, close observation is necessary in places in order to discriminate between

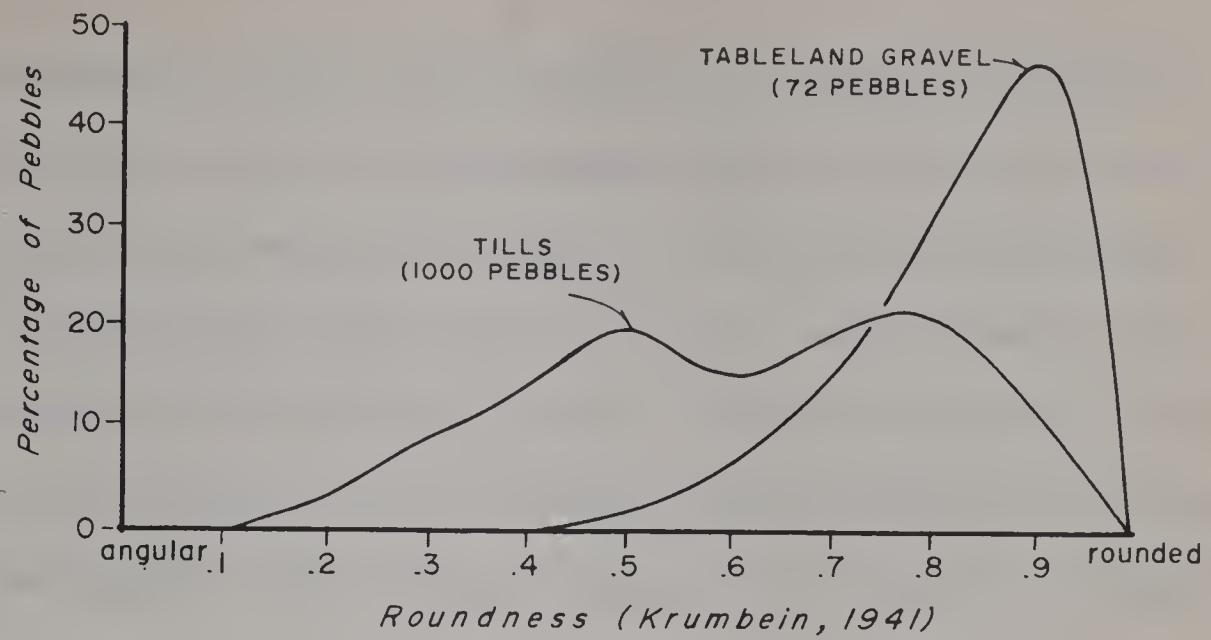


FIGURE 17 - Graph showing difference in roundness of metaquartzite pebbles in Tableland Gravel and in tills.

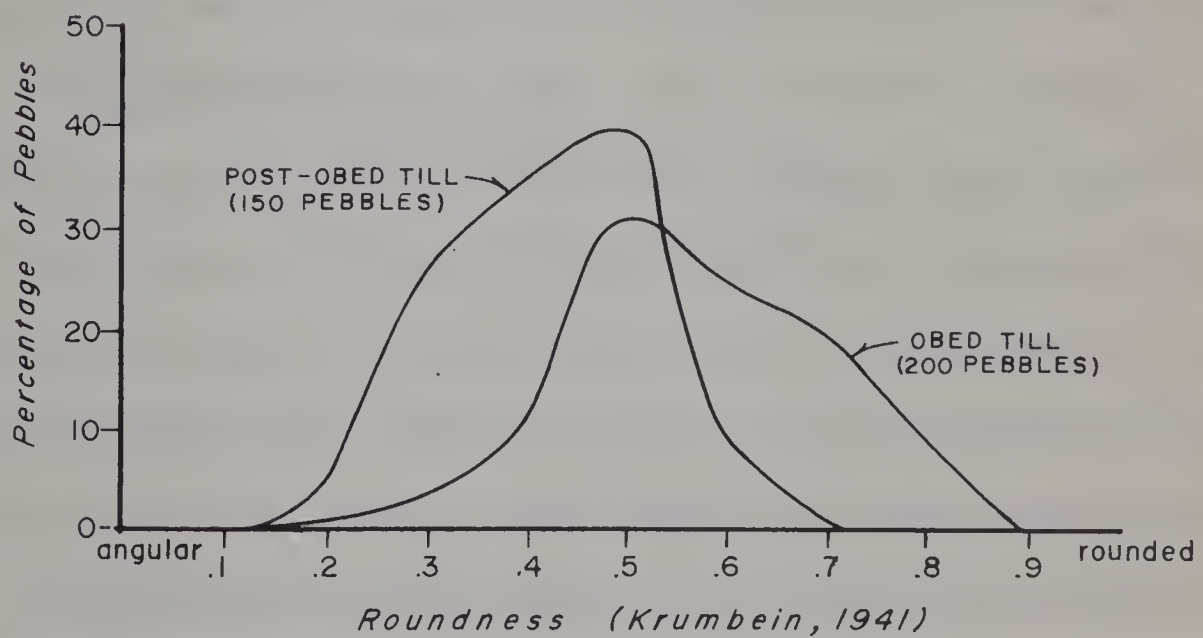


FIGURE 18 - Graph showing difference in roundness of limestone pebbles in Obed till and Drystone Creek till

till and gravel. Muskeg and alluvial deposits overlie the till in valleys and poorly drained depressions.

With decrease in pebble content combined with a general increase in crystalline erratics and a decrease in metaquartzite erratics towards the south and north, Mayberne till passes laterally into Edson till. Near the western boundary of the Mayberne Tableland the Mayberne till is in contact with the Marlboro till, although this relationship was not directly observed. The same stratigraphic relationship exists between the Mayberne and the Marlboro tills as that which exists between the Edson and Marlboro tills which has been discussed under the section on Edson till.

(4) Geomorphology - The geomorphic expression of the Mayberne till is mainly in the form of ground moraine. Two additional features of the Mayberne till are noteworthy. The first feature is the set of extensively developed crescent-shaped end moraines preserved in Nose Hill Creek valley (Figure 3). The end moraines are referred to as lobate end moraine and are composed of till. They are crescent-shaped in plan with the convex side up Nose Hill Creek valley. They form narrow ridges ten to fifteen feet high and up to fifty feet wide at the base. Shallow troughs between the ridges range in width between fifty feet and three hundred feet. Associated with the lobate end moraines are ridges which are orientated nearly at right angles to the moraines (Figure 3). Except for their linear outline these ridges, which are probably composed of till, appear to be similar to the lobate end moraines but they have not been examined on the ground. The end moraines record the presence of a lobe of Continental ice which advanced from the north up the valley of Nose Hill Creek (the arcuate shape of the moraines is used as a flow direction indicator as shown in Figure 16). The second notable feature in the Mayberne till is the presence of thick deposits (over 10 feet) of till which are marked by sub-parallel, narrow, irregular depressions

and ridges resembling minor recessional moraine (Christiansen, 1956, p. 13) and referred to as lateral moraine (Flint, 1957, p. 131). The lateral moraine has a local relief of less than ten feet and occurs along the valleys of Windfall Creek, Pine Creek and Beaver Creek (Plate 3). Gimbarzevsky (1966, Fig. 2) has a good illustration of this till landform located in Sec. 26, Tp. 57, R. 19 W5 but he refers to it as "slump topography - glacial till deposits".

(5) Origin - The Mayberne till was deposited on the Mayberne Tableland by the same Continental glacier that deposited the Edson till on the Edson Lowland. The till therefore is a lithofacies equivalent of the Edson till.

Marlboro Till

(1) Definition - The Marlboro till is by far the most widespread glacial deposit in the area. It is the principal surficial deposit of the Athabasca Tableland, the northern part of Athabasca Benchland, Rocky Mountain Foothills, Pinto Tableland, the southern part of Wildhay Benchland, and the western parts of Edson and Pembina-McLeod Benchlands. The till is named after the hamlet of Marlboro, and the type section is located one and one-half miles southwest of the hamlet in a south-facing cutbank of the McLeod River valley (SW 1/4 Sec. 36, Tp. 52, R. 20 W5). At the type section (Locality No. 187) 20 feet of Marlboro till overlies sandstone of the Paskapoo Formation. The till ranges in thickness from one foot over uplands to over one hundred feet in buried valleys but the most common thickness is about ten feet.

(2) Lithology - Lithology of the Marlboro till shows a wide range throughout the area but at the type locality (Sample No. 187) the till is very slightly plastic when moist,

dusky yellow to pale olive, moderately stony, containing pebbles with a mode of one inch in diameter, but cobbles up to six inches in diameter are present. Pebbles are composed mainly of limestone, orthoquartzite and feldspathic orthoquartzite, meta-quartzite and lithic sandstone. Texturally the till is classified as clay, but categories of loam, clay loam and sandy loam also characterize the Marlboro till at other localities. Carbonate content averages 13 per cent for six samples. Heavy minerals in the Marlboro till are typical of a Cordilleran source (Figure 12, and Table 4, Appendix A) being mainly zircon and garnet; some chlorite and rutile also occur but hornblende is lacking.

The variation in erratic composition in the Marlboro till is considerable and offered much difficulty during preliminary stages of mapping. Some problems remain at the time of writing. Where Tableland gravel underlies the Marlboro till, a large percentage of metaquartzite pebbles is characteristic of the till. This is displayed in much of the Athabasca Tableland north of the Athabasca River, especially in the vicinity of the Obed Fire Tower and near the headwaters of the Oldman Creek. At many localities limestone is lacking; also, the limestone content may drop from twenty per cent to zero in several hundred yards.

Two uncommon rock types in the till have been found at two separate localities. One is a subrounded cobble of porphyritic basalt collected from ice-content deposits in SW 1/4 Sec. 16, Tp. 53, R. 19, W5. This rock type was also found independently by Dr. L. Halferdahl, Research Council of Alberta, in alluvium along the McLeod River in the vicinity of Bickerdike. The basalt occurs in an area which does not exclude the possibility of a Canadian Shield source, but apart from this, the only explanation offered is that the basalt is derived from reworking of the Tableland

gravel. The other distinctive rock type is hematitic pisosparite (light and dark coloured varieties) found in NW 1/4 Sec. 18, Tp. 53, R. 19, W5. Two large angular blocks were found. These erratics likewise occur near the contact of Cordilleran-Continental till, but they have been traced to a source in the Rocky Mountains (E. W. Mountjoy, personal communication, November 13, 1965). The hematitic pisosparite is believed to have come from a carbonate horizon near the top of the Miette Group of Precambrian age (Mountjoy, 1962, p. 5), which is most noticeable on Yellowhead Mountain. Mountjoy remarked that "to my knowledge there is no other carbonate like this and none occurs on the B. C. side of the Rockies" (personal communication, November 13, 1965).

Throughout most of the Athabasca Tableland north of Athabasca River, the Marlboro till contains a variety of low to medium grade metamorphic rocks. Some typical localities and general distribution of the erratics are given in Figure 5. The most abundant rock type is talcose schist with lesser amounts of garnet schist and quartz biotite schist (Table 1, Plate 1). These erratics have been referred to as the Athabasca Valley Erratics Train by Roed et al. (1967). This erratics train indicates that for a period of time the source for Cordilleran ice (part of the Marlboro glacier of this study) in the Rocky Mountains of Jasper National Park area was west of the Continental Divide and Rocky Mountain Trench, and that the main provenance of the erratics was the Premier Group and portions of the Monashee Mountains (Figure 5).

Erratics composed of light green talcose schist, one component of this erratic train, are not restricted to the limits outlined in Figure 5 because they have been found adjacent to the McLeod River in the Pembina-McLeod Benchland. Erratics of at least two different metamorphic rock types described above should be present

Table 1

ROCK TYPES OF ATHABASCA VALLEY ERRATICS TRAIN

<u>Locality</u> (See Figure 5)	<u>Metamorphic Rock Types</u>	<u>Altitude</u>	<u>Deposit</u>
1	1. Silvery light grey talcose schist 2. Light grey quartz biotite schist 3. Light greenish-grey talcose quartz schist, minor biotite and muscovite	3500	Ice-contact outwash; fragments 1/4 inch to 2 feet in diameter mode 1½ inches in diameter mainly subangular; many highly weathered boulders
2	1. Muscovite quartz schist, some chlorite	3750	Till; boulders up to 2 feet in diameter, clayey matrix, most erratics from Rocky Mountains
3	1. Chlorite quartz schist 2. Muscovite quartz schist 3. Muscovite quartz schist 4. Talcose schist	3300	Outwash from Cordilleran glacier, end moraine complex
4	1. Garnet talcose schist, garnets up to 5mm 2. Hornblende garnet quartz gneiss	5187	Till; boulders up to 4 feet in diameter; less than 2 feet thick, clayey and sandy
5	1. Talcose muscovite garnet schist, garnets up to 7mm 2. Biotite quartz schist	3400	Till, boulders up to 3 feet in diameter
6	1. Talcose muscovite schist 2. Talcose garnet schist, garnets up to 3mm 3. Talcose biotite garnet schist, garnets up to 4mm	4100	Till, boulders up to 2 feet in diameter
7.	1. Talcose garnet schist 2. Biotite quartz schist 3. Talcose sericite schist	3800	Till, boulders up to 3 feet in diameter

in the Athabasca Valley Erratics Train. Also, the erratics train is not restricted to Marlboro till; it also occurs in the younger Obed till.

Further implications of the Athabasca Valley Erratics Train arise upon consideration of the Erratics Train, Foothills of Alberta (Stalker, 1956). This subject is considered in Appendix B.

The lower part of the Marlboro till contains erratics of crystalline rocks of Canadian Shield origin at some localities. These erratics seem to be confined to the northern and eastern extremities of the Marlboro till (marked by the symbol GR in Figures 2 and 3) in the Wildhay and Athabasca Benchlands and in the northern part of the Athabasca Tableland. A stratigraphic section which partially explains their presence is given in the Oldman Section (No. 271). At this locality, Marlboro till containing rare granite pebbles overlies outwash of Continental origin (Marsh Creek outwash) which in turn overlies Marsh Creek till also of Continental origin. The presence of crystalline rocks of Canadian Shield origin is therefore explained since Continental ice invaded this part of the area before the Cordilleran advance which deposited Marlboro till.

(3) Stratigraphic Relationships - In places the Marlboro till overlies bedrock (Section No. 188) and in other places it overlies Tableland gravel (Obed Fire Tower). In the Oldman Creek section (No. 271) Marlboro till overlies glacial outwash gravel of Continental source (Figure 14) and in the McLeod River Valley it overlies outwash of Cordilleran source (NW 1/4 Sec. 5, Tp. 51, R. 22, W5). In the Athabasca Benchland and the river valley, Marlboro till lies beneath the Pedley sediments, which in turn is overlain by Obed till (Section Nos. 67, 188 and 246). At some localities Obed till

may rest directly on Marlboro till. This relationship can be seen in several places along the Canadian National right-of-way between Pedley and Obed. Also, at the Obed Lake Section (Section No. 239) Obed till is believed to overlie Marlboro till directly, but till samples of this section have been analyzed and results (heavy minerals, pebble composition, carbonate content) indicate that there are no real differences between the tills at this location. The Obed till and the Marlboro till (Figure 14) can be distinguished in the subsurface by superposition only where the two units are separated by the Pedley sediments.

Along Highway 16 the contact between Marlboro till on the east and Obed till on the west falls somewhere within Sec. 34 and 35, Tp. 52, R. 20 W5. The visible differences in the tills in this general vicinity are twofold. The Obed till has many more stones and many more limestone pebbles than the Marlboro till. Also, the Obed till has a more sandy matrix than the Marlboro till. In SW 1/4 Sec. 7, Tp. 54, R. 23 W5 the contact is much more abrupt and can be drawn within one hundred yards. It is marked by the same features as mentioned above but the differences are even more pronounced since the Marlboro till is very clayey at this locality and limestone pebbles are very rare; in contrast, the Obed till is sandy and contains numerous limestone pebbles. Also, this contact is well marked geomorphically since lateral moraine of the Obed till can be traced for at least six miles along the edge of the tableland in this area (Figure 2).

The "truncation" of the easterly and southeasterly trending drumlins, grooves and flutings in the Marlboro till by northeasterly trending drumlins and grooves present in the Obed till is vividly displayed near the line of junction of the Athabasca

Benchland and the Athabasca Tableland from as far west as Jasper Park Boundary east to Obed. As stated in the preceding paragraph this contact is also marked in places by lateral moraine of the Obed till and a lithologic break between the tills. However, the lithologic break is not convincing at all localities, especially south of Hinton.

The contact between the Marlboro and Obed till can also be located in the Jarvis Lake Valley but only in rare instances. The main reason for this is the scarcity of exposures and the similarity of geomorphic expressions of the till units.

Laterally, the Marlboro till passes abruptly into Edson till and Mayberne till. This contact is discussed under Edson till and is not discussed further here (Figure 15).

Although transitional and uncertain in detail, the contact between the Marlboro and Raven Creek tills is well illustrated along the lumber road in the vicinity of Sec. 23, 25 and 26, Tp. 48, R. 17, W5. Here the contact is marked by the appearance of crystalline rocks of Canadian Shield origin characteristic of the Raven Creek till. There are no other obvious changes. That the two units are correlative lithofacies deposited by a single glacier follows from a consideration of the contact of the tills and of the ice-movement indicators shown in Figure 16. There is no discernable discordance in the trends of drumlins, grooves and flutings of the two tills. The ice flow pattern strongly suggests one glacier movement as shown in Figure 16. From regional mapping the contact of the Marlboro and Raven Creek tills is inferred to cut across up to one thousand feet of topography from the Pembina-McLeod Tableland to the Edson Lowland. This alone demands that the tills be the deposit of one mass of ice.

(4) Geomorphology - The geomorphic expression of the Marlboro till is in many ways spectacular. In the northern part of the Athabasca Tableland there is a well defined system of lobate end moraines composed of Marlboro till. The best formed moraine straddles the north-flowing Oldman Creek (Plate 16) and is made up of a discontinuous series of parallel crescent-shaped low ridges of till less than fifteen feet in height and 100 feet wide at the base. The distance between individual ridges may be as much as one mile. Intervening depressions are nearly flat and contain muskeg. This lobate end moraine records the presence of part of a piedmont ice lobe which deposited the Marlboro till. That there was another lobe of ice, probably of large dimensions, is shown by the presence of a less distinct but similar pattern of lobate end moraine located to the northwest in Tp. 54 and 55, R. 25, W5. However, the western part of this lobate moraine was either eroded by meltwater streams or buried by outwash deposits where the moraine intersects the valley of the Wildhay River. Till ridges along the eastern part of this lobate moraine intersect the till ridges along the western part of the lobate end moraine straddling Oldman Creek. This is especially evident in Sec. 14, 15 and 16, Tp. 54, R. 24 W5 (Plate 16).

Intersecting till ridges, interpreted as till crevasse fillings, occur at the junction of R. 22 and 23, Tp. 55, north of Oldman Creek. Patches of hummocky dead-ice moraine composed of knobs, kettles and till ridges (Plate 16) do occur in the Marlboro till but this landform is quite rare.

Apart from flutings, grooves and drumlins, the only other geomorphic features in the Marlboro till are "circles" (described in the section on small-scale landforms) which can only be detected on aerial photographs. The "circles" are not restricted to Marlboro till since similar features have been recorded in Obed till.

Marlboro till forms the main surficial material of an extensive fluted surface (or "plain") in the southern part of the area. The surface is part of the Pembina-McLeod Benchland and is characterized by well formed drumlins, flutings and intervening grooves. Glacier movement from many of these ice-flow features has been interpreted in Figure 16.

(5) Origin - The Marlboro till was deposited by a Cordilleran glacier of large dimensions. This ice advanced out of the Athabasca River valley and spread out over benchlands, tablelands and foothills. In the north and east part of the area the Marlboro glacier came into direct contact with the Continental ice sheet which deposited the Edson and Maybeerne tills. This contact forced most of the ice emerging out of the Athabasca Valley to move towards the southeast. These conditions may have persisted for a very long time, long enough for the southeasterly flowing ice stream to flow three hundred and fifty miles to beyond the International Boundary, or these conditions may have persisted for only a short while and affected little more than the Edson-Hinton area. The former interpretation is preferred by the writer but there is no direct proof of its validity.

Raven Creek Till

(1) Definition - The Raven Creek till occupies the southeastern part of the area, forming the surficial deposit of part of the Pembina-McLeod Benchland and the Pembina Tableland. The till is named after Raven Creek, a small tributary of the Erith River. The type locality is on the north facing slope of a dissected drumlin in SE 1/4 Sec. 7, Tp. 50, R. 16, W5 (Locality No. 229) where five feet of Raven Creek till overlies

soft lithic sandstone of the Paskapoo Formation. The till ranges in thickness from one foot to 50 feet along the Pembina River valley.

(2) **Lithology** - The till at the type locality is slightly plastic when wet, medium green grey to brown grey, moderately stony with a pebble mode of one inch in diameter, and cobbles up to ten inches in diameter. Pebble lithology includes metaquartzites, lithic and quartzose sandstone, limestone, dolomite, orthoquartzite and feldspathic orthoquartzite, and pink granite. Texturally, the till matrix is classified as a clay loam, but categories of sandy clay loam and loam also occur at some localities. Carbonate content is only five per cent but the average of four samples at different localities is eleven per cent, and the heavy mineral suite is dominantly of Cordilleran character (Table 2, Figure 12) although three per cent hornblende is present at the type locality. Hornblende is foreign to Cordilleran tills of the area but characteristic of Continental tills.

The Raven Creek till is considered to be a lithofacies equivalent to the Marlboro till. The only obvious difference in the tills is that the Raven Creek till contains erratics of crystalline rocks derived from the Canadian Shield. These erratics do not make up more than one or two per cent of the pebbles and in some sections (No. 210) they have not been observed.

(3) **Stratigraphic Relationships** - The lower contact of the Raven Creek till is not well known. Along the banks of the Pembina River the till overlies outwash gravel (Figure 14) and in most other places examined it rests upon bedrock. From the results of this study it is expected that Continental till (possibly equivalent to the Marsh Creek till) will be found below the Raven Creek till. This till is overlain locally by outwash deposits,

glaciolacustrine deposits, aeolian sand, and muskeg. Laterally toward the northwest, Raven Creek till grades into Marlboro till upon disappearance of crystalline rocks. To the northeast the Raven Creek till grades into the Mixed till, however, this gradational contact has not been observed (see Mixed till).

(4) Geomorphology - Raven Creek till occupies an area characterized by southeasterly trending drumlins, flutings and grooves, which have been deeply dissected in places by northeasterly trending ice-marginal channels. A few eskers and kames mark the surface in places and some "circles" are present. Much of this till, however, is covered by thick forest stands, thereby rendering observation of geomorphic expression difficult or impossible.

(5) Origin - The Raven Creek till was deposited by the same glacier as the Marlboro till, but the Raven Creek till is believed to occupy an area in which Continental till had been deposited prior to the Cordilleran ice advance which deposited the Raven Creek till. The distribution of crystalline rocks of Canadian Shield origin in the Raven Creek till (see page 131) is believed to be evidence of this Continental ice advance which was of greater extent than the latest advance recorded by Edson and Mayberne tills. This is supported by the occurrence of Marsh Creek till and the rare Canadian Shield erratic in the Marlboro till. Therefore, it is very likely that a correlative of the Marsh Creek till underlies the Raven Creek till.

Mixed Till

(1) Definition - The Mixed till occupies a small area in the southeastern parts of

the Edson Lowland and Pembina-McLeod Benchland. The till is named in accordance with its stratigraphic position adjacent to Cordilleran Raven Creek till on the west and Continental Edson till on the east. It is "intermediate" in composition between these two tills. The type locality is at an oil well site in SW 1/4 Sec. 26, Tp. 51, R. 15, W5 where about five feet of this till (locality No. 223) overlies the Paskapoo Formation. The range in thickness is not known but the till probably has an average thickness of 10 feet. The Mixed till is not well known due to lack of accessibility and good exposures.

(2) Lithology - The till is plastic, medium olive brown, moderately stony, containing pebbles with a mode of three-quarters of an inch but with boulders up to one and one-half feet in diameter. Pebbles of a Cordilleran source, especially limestone, and of Continental source are both well represented (Figure 12). Heavy minerals of Continental source, namely hornblende and hypersthene, and of Cordilleran source, zircon and tourmaline, are common. Carbonate content is 0.7 per cent. Texturally the till is classified as a clay loam.

(3) Stratigraphic Relationships - Neither the lower contact (except at the type locality) nor the upper contact has been observed but the Mixed till is overlain by glaciolacustrine sediments and aeolian sand in places. Laterally the till is inferred to grade into the Edson till on the east and into the Raven Creek till on the west. These gradational contacts have not been directly observed.

(4) Geomorphology - Much of the area occupied by the Mixed till is characterized by drumlins, flutings and grooves. Northern drumlins record a southeasterly glacier flow but in a direction 15° further to the south than drumlins in the adjacent Raven

Creek till (Figure 3). The northern drumlins probably reflect the influence of Continental ice movement as is interpreted in Figure 16, and the southern drumlins are believed to represent the uniform flow direction of combined southeastward moving Cordilleran and Continental ice.

(5) Origin – The Mixed till represents the deposit of a mixed zone which was occupied by both Cordilleran and Continental ice as shown in Figure 5.

Obed Till

(1) Definition – Obed till occupies the western part of the Athabasca Benchland, part of the McLeod Benchland and Jarvis Lake Valley between elevations of 4300 and 3500 feet. It is named after the hamlet of Obed, which is the highest point on the Canadian National Railway across Canada (elevation 3562 feet). The type locality is in SW 1/4 Sec. 3, Tp. 52, R. 24 W5 on a south facing bank of Trail Creek (Section No. 188) where the Obed till is sixteen feet thick. The average thickness is approximately fifteen feet but in NW 1/4 Sec. 5, Tp. 51, R. 25 W5, the Obed till is one hundred and forty-five feet thick (Section No. 125).

(2) Lithology – Lithology of the Obed till is quite uniform. At the type section (Section No. 188, units 17 and 18) it is moderately olive brown where oxidized and olive black where unoxidized, slightly plastic, very stony, and containing pebbles with a mode of one and one-half inches but with boulders up to three feet in diameter (Plates 17 and 18). Pebbles are all of Cordilleran origin, composed dominantly of limestone, orthoquartzite, feldspathic orthoquartzite, lithic sandstone, and some metaquartzite; some light grey talcose schist and garnet schist occur in places. The textural classification of the till is mainly clay loam, but categories of loam and sandy loam also

occur. The heavy minerals are typical of Cordilleran origin in that they include abundant zircon, garnet, epidote, and lack hornblende which is characteristic of Continental tills (Figure 12). Carbonate content ranges from 18 to 30 per cent and averages 20 per cent for seven samples.

Erratics of the Athabasca Valley Erratics Train are common in the Obed till occurring as pebbles and boulders within the till and also on the surface of the deposit. In fact, some of the best examples of these erratics are found in the Obed till and associated outwash deposits. These erratics are concentrated mainly in Jarvis Lake Valley and the north part of Athabasca Benchland but are particularly common in the vicinity of Brule and Wildhorse lakes. Good examples also occur east of Peppers Lake. For this reason it is inferred that not all of the Marlboro ice melted in the Athabasca River valley west of the area so that ice that originally formed part of Marlboro glacier is inferred to have also formed some part of the Obed glacier. Alternatively the Obed glacier may have reworked part of Marlboro till but this explanation is unlikely upon consideration of the weak and incompetent nature of the schistose erratics.

(3) Stratigraphic Relationships – The Obed till overlies bedrock along the flanks of the Athabasca Benchland but at many localities, including the type section, the till rests on a group of interstadial deposits referred to as the Pedley sediments. In the vicinity of Galloway near the easternmost occurrence of the Obed till, the till overlies outwash deposits which are correlated with the Marlboro delta (Section No. 238). Marlboro till is believed to underlie the Obed till directly at a number of localities, but as has been discussed in the text on Marlboro till, this has not been substantiated

(by laboratory analysis) since the two tills are commonly similar in lithology.

The Obed till is overlain by a wide range of deposits which include outwash, aeolian, and glaciolacustrine sediments and muskeg. The most prominent outwash deposits overlying the Obed till consist of valley train gravel deposits forming the Hinton Terraces, which are related to the retreat of Obed ice. The terrace deposits overlie the Obed till adjacent to the Athabasca River valley from Entrance to Pedley. Erosional remnants of the Obed till surrounded with gravel of the terrace deposits are a common topographic feature in the vicinity of Hinton.

Contacts between the Marlboro and Obed tills are discussed in detail in the text under Marlboro till.

(4) Geomorphology - Landforms associated with Obed till include drumlins, flutings, grooves, lateral moraine, lobate end moraine, and "circles". Northeast trending drumlins are well developed in the Obed till within the Athabasca Benchland. The drumlins have a bedrock core in places (crag and tail) and are also formed completely of till or outwash deposits at other localities. Along the eastern margin of the Obed till drumlins indicate that the glacier "expanded" to the north, east and southeast. "Truncation" of pre-existing ice-flow indicators is discussed in the text under Marlboro till.

Lateral moraine of low relief, composed of Obed till occurs within the Athabasca Benchland at Sec. 5, Tp. 5, R. 26; Sec. 14, Tp. 52, R. 23, and northwest of Hinton along the northern part of the benchland. Distinct lobate end moraine comprising part of the terminal moraine of Obed till can be observed on aerial photographs of the area north of Apetowun Creek in Tp. 54, R. 23. "Circles"

are well developed in the Obed till in Tp. 52, R. 25, but are not common elsewhere (Plate 7). Obed till also occurs as inclusions in the extensive pitted outwash in the Jarvis Lake Valley.

(5) Origin – Some of the same ice which composed the Marlboro glacier made up part of the Obed glacier as indicated by the Athabasca Valley Erratic Train so it is more likely that the Obed till represents a major re-advance and reactivation of the Marlboro glacier rather than a completely separate advance. This re-advance probably did not occur until a considerable interval of time had elapsed, enough time to deposit the Pedley Sediments and the Plante Creek Sediments. From the distribution of Obed till and the geomorphic expression it is believed that it was an expanded toe glacier. Continental ice had apparently retreated from the area by the time of the glacier advance.

Obed till is dominated by pebble lithologies characteristic of the Front and Main Ranges of the Rocky Mountains which suggests that these ranges contributed most of the ice to the Obed glacier, in contrast to a much larger source of ice for the Marlboro glacier.

Drystone Creek Till

(1) Definition – Drystone Creek till occurs in small valleys which usually head in cirques along the Front Ranges and Foothills of the Rocky Mountains. Since there are no age dates available, and since the outwash associated with the till overlies an erosional surface of the Obed till (Figure 2) it is recognized as a separate rock stratigraphic unit. The type locality (Section No. 39, Unit No. 1) is along an east facing cutbank of Drystone Creek in NE 1/4 Sec. 18, Tp. 49, R. 26 W5 where

the till is at least twenty-five feet thick. Drystone Creek till also occurs in Solomon Creek valley and other small valleys in that vicinity.

(2) Lithology - At the type locality Drystone Creek till is brownish grey to medium grey, very stony, containing boulders up to four feet in diameter, with a pebble mode of one inch. Most of the pebbles are limestone but quartzite, lithic sandstone and siltstone do occur. Pebbles are characteristically subangular. Texturally, the till is classified as clay loam. Carbonate content is exceptionally high averaging 45 per cent for two samples. Heavy mineral recovery was disappointing, but the minerals represent a Cordilleran source (Table 4).

The Drystone Creek till differs from the Obed till in that the former has a much higher carbonate content, contains pebbles derived mainly from local bedrock, and the pebbles are more angular than pebbles in the Obed till (Figure 18, Table 7).

(3) Stratigraphic Relations - Outwash gravel underlies Drystone Creek till in the valleys of Drystone Creek (Locality No. 36) and Solomon Creek. The outwash may be related to retreat of Obed ice or may have been deposited during advance of ice which formed the Drystone Creek till. Drystone Creek till forms the surface deposits in most localities where it occurs but in places it is overlain by colluvial material. The contact between Obed and Drystone Creek till has not been observed.

(4) Geomorphology - Geomorphic expression of the Drystone Creek till is recognized on aerial photographs where the till partly infills valleys. Contacts between the till and valley sides can therefore be drawn with some accuracy. Other geomorphic

features of the till apart from ground moraine have not been observed.

(5) Origin - Alpine glaciers of local extent in the Front Ranges and Foothills of the mountains deposited the Drystone Creek till. Although correlation is in doubt, the Drystone Creek till is believed to be younger than Obed till because Obed till near the valley of Drystone Creek in SW1/4 Sec. 19, Tp. 49, R. 26, W5 has been eroded by meltwater which may have been derived from the glacier which deposited the Drystone Creek till.

Other Stratigraphic Units

General Remarks

Other stratigraphic units that are recognized in the area include sub-surface Pleistocene interstadial sediments, glaciofluvial deposits, glaciolacustrine deposits, and nonglacial Recent deposits.

Subsurface Interstadial Sediments

General Remarks

Subsurface interstadial sediments are recognized in the subsurface and do not commonly form a surface deposit in the area. These sediments are recognized by their stratigraphic position between tills of different ages, and by their lithology, that indicates a climatic episode during which a secondary recession or a stillstand of glaciers took place (American Commission on Stratigraphic Nomenclature, 1961). In the Edson-Hinton area these interpreted interstadial sediments (Table 8) may be of interglacial rank but since age dates are lacking, these sediments are referred

tentatively to interstadial status. Three units of interstadial sediments have been recognized on the basis of the factors outlined above and are the Marsh Creek outwash, the Pedley sediments, and the Plante Creek sediments.

Marsh Creek Outwash

(1) Definition and Lithology - Marsh Creek outwash is underlain by Marsh Creek till and overlain by Marlboro till at the type locality (Section No. 271, Unit No. 2) in NW 1/4 Sec. 13, Tp. 55, R. 23, W5. It is 20 feet thick and is mainly a bedded pebbly gravel which may contain some ice-contact deposits in the lower part.

Quartzite pebbles of Cordilleran source, dominantly of metaquartzite variety, and pebbles composed of crystalline rocks of Canadian Shield source are common (Table 5, Sample No. 271-2). Heavy minerals are typical of a Continental source but an unusually high percentage (23 per cent) of hornblende is present relative to the quantity of this mineral in other units of Canadian Shield source in the area.

(2) Origin - The Marsh Creek outwash deposit is known only from the type locality. The unit is believed to have been deposited during the retreat of the glacier which deposited the underlying Marsh Creek till. The Marsh Creek till represents the earliest known advance of Continental ice, and was of greater extent than the one that deposited the Edson and Mayberne tills. Marsh Creek outwash underlies Marlboro till so that the outwash predates this major Cordilleran ice advance. An interstadial designation of the Marsh Creek outwash is therefore recognized.

Pedley Sediments

(1) Definition - The Pedley sediments are a complex and lithologically variable group of deposits which are widespread within the Athabasca Benchland from

Entrance in the west to as far east as Obed Lake, and possibly Galloway. The sediments are named after the hamlet of Pedley near the type section. The type section is located on a south facing bank of Trail Creek in SW 1/4 Sec. 3, Tp. 52, R. 24, W5 where the unit is 30 feet thick (Section No. 188, Unit Nos. 7 to 16, inclusive) and is overlain by the type Obed till and underlain by Marlboro till. Pedley sediments range greatly in thickness from 15 feet in Section No. 67 to over 55 feet at Section No. 125 (Figure 11).

(2) Lithology and Stratigraphic Relations - Lithology in the Pedley sediments is highly variable. At the type section the unit consists of a series of fine-grained sand, silt, some pebbly gravel, minor clay and till interbeds (for detail description see Section No. 188) whereas one and one-half miles to the north, at Section No. 67, the unit is entirely gravel. Near Hinton (Plate 19) the upper part of these sediments is composed of laminated clay. The till interbeds included in the Pedley sediments at the type locality may represent minor readvances of ice, or they may represent deposits from mudflows in a superglacial environment or deposits from icebergs in a glaciolacustrine environment of deposition. Sedimentary structures in the sand beds of the Pedley sediments include small-scale cross strata, and pebbles "floating" (possibly ice-rafted) in sand and silt units are common.

Similar sedimentary units, namely clay, silt, sand and minor till are present in the Plante Creek Section (No. 246). Marlboro delta deposits located west of Edson are shown as time equivalent to the Pedley sediments in Figure 14 but the Marlboro delta represents the initial deposits of the interstadial, whereas the Pedley sediments represent the main deposits of the interstadial and are believed to be younger than the deltaic unit.

(3) Origin - The Pedley sediments were deposited by glacial streams and in local lacustrine basins after the retreat of Marlboro ice and before the advance of the Obed glacier.

The character of the Pedley sediments, specifically the interbedded and discontinuous clay, silt, sand and gravel, cross-bedding and "floating" pebbles suggest that deposition took place not too far from the ice front and that drainage was blocked by Continental ice to the northeast which caused periodic ponding and subsequent flooding forming this complex group of sediments within the Athabasca Benchland.

Plante Creek Sediments

(1) Definition - The unit of interbedded clay and sand which occurs between the Obed till and the Marlboro till in Plante Creek valley is referred to as the Plante Creek sediments. The type section (Section No. 246, Units 2 to 6) is located in a west-facing bank on the east side of Plante Creek valley, after which the unit is named (NE 1/4 Sec. 1, Tp. 54, R. 23 W5). At the type section the unit is 33 feet thick but may be up to 50 feet thick at other exposures along the valley.

(2) Lithology and Stratigraphic Relationships - The Plante Creek sediments at the type section are made up of beds of dark grey, silty clay 2 to 7 feet thick alternating with beds of fine grained, light grey sand 0 to 11 feet thick. Structures in the clay consist of vague banding and minor contorted bedding; rare pebbles are found "floating" in the clay. Most of the sand beds exhibit poorly defined banding but the upper sand beds (units 6 to 8 of Section No. 246) contain small to medium

scale cross-beds. A lense of till-like material is included in the sequence of Plante Creek sediments (Section No. 246, Unit 7), but it is not known whether this unit was deposited as a mudflow, from an iceberg, or directly from glacial ice. At other localities in Plante Creek valley, the sediments consist mainly of dark grey silty clay.

The Plante Creek sediments are overlain by typical Obed till (Figure 2) and underlain by Marlboro till in which limestone erratics have not been observed. The unit lies in the same stratigraphic interval as the Pedley sediments.

(3) Origin - The clay and sand beds of the Plante Creek sediments were deposited in a lacustrine basin located in the lowland of Plante Creek valley. The presence of "floating" pebbles in the clay and the till-like layers in the sequence suggests that the lake was close to a glacier that probably contributed to damming of the lacustrine basin. The Plante Creek sediments record a period of climate change in the time after retreat of the Marlboro glacier and before advance of the Obed glacier, and probably represent the same interstadial as the Pedley sediments.

Glaciofluvial Deposits

General Remarks

Extensive glaciofluvial deposits occur in the area as shown in Figures 2 and 3. They can be subdivided into major groups on the basis of morphology, origin and general lithology. Glaciofluvial units are not overlain by till;

they are distinguished from interstadial deposits in this way. The stratigraphic units recognized are the gravel deposits of the terraces flanking the Athabasca River in the vicinity of Hinton and Entrance, and the numerous outwash deposits in the area.

Hinton Terrace Gravels

Terraces composed mainly of gravel are common along meltwater channels in the area. Excellent examples of outwash terraces occur above the Athabasca River between Pedley and Entrance within the Athabasca Benchland. These terrace gravels have been studied by Stene (1966); the following account is a modified summary of his work.

Two large paired outwash terraces, referred to as the Hinton Terraces, are present in the Athabasca Benchland between Pedley and Entrance. The two terraces both represent valley train gravel deposits formed during the retreat of the Obed glacier. The upper terrace is at an elevation of approximately 3300 feet at Hinton, 200 feet above the Athabasca River and can be followed up the valley where it is found to grade into the Maskuta Creek kame moraine. The lower terrace occurs at an elevation of about 3200 feet at Hinton, 100 feet above the Athabasca River. This terrace is related to an end moraine (Secs. 30, 31, Tp. 50, R. 26, W.5) west of Entrance.

Both terraces are composed of two gravel units of pebble to cobble size. The lower unit is characterized by medium scale, high angle trough cross-bedding. The upper unit, in contrast, exhibits parallel bedding (Plates 10 and 11). Gravel in the lower unit is more poorly sorted than the gravel of the upper unit. The general

interpretation presented here is that the lower unit represents rapid changes in discharge of meltwater with formation of the medium scale cross strata in the lower part of the upper flow regime in shallow water (Simons and Richardson, 1961). The upper parallel bedded gravel unit is more of a problem. The gravel can be classified in part as openwork since it lacks matrix in some sections. This, along with the parallel bedding, suggests deposition in the upper flow regime probably in deeper water than interpreted for the lower gravel unit, and under more uniform discharge. Therefore both gravel units of both terraces record, firstly, a period of swift moving but rapidly fluctuating glacialfluvial stream flow; then, secondly, a period of constant or sustained high flow conditions in deeper water. The source of the gravel may be partly from reworked Obed till, which is very stony and has been deeply eroded in the general vicinity, and partly from debris within the ice.

Numerous other terrace gravels occur in the Edson-Hinton area along major rivers; most of these are shown in Figures 2 and 3.

Outwash Sand and Gravel

Outwash deposits composed of sand, gravel, or undifferentiated sand and gravel occur in outwash plains and meltwater channels in the area.

(1) Outwash Sand - Outwash sand is extensive on the Wildhay Benchland and is composed of cross-stratified and parallel bedded sand (Plates 20 and 21) with some gravel lenses. Detailed descriptions of this deposit are given in Sections No. 273 and 277. Outwash in this area is related to the retreat of both Obed and Marlboro

glaciers and other glaciers which may have occupied the Wildhay River and Pinto Creek valleys. The thickness of this deposit varies considerably but in the Wildhay River section the sand is 60 feet thick.

(2) Outwash Gravel - Outwash gravel is found in many of the meltwater channels and outwash plains in the area (Figures 2 and 3). Meltwater channels may be formed in an ice-marginal position or they may be formed away from a glacier. Examples of the former are the deep northeasterly trending meltwater channels which have been eroded into the Pembina-McLeod Benchland. Gravel has been deposited in all of these meltwater channels but only rarely is the gravel exposed. These meltwater channels originated along the southern margin of the glacier which deposited the Raven Creek till. A more spectacular meltwater channel is located along the course of Sundance Creek. The Sundance Creek meltwater channel was formed at the eastern edge of the Marlboro glacier (very likely in contact with the Edson glacier at the time) and was eventually eroded at least 400 feet into the bedrock in places. Gravel is expected at the bottom of the channel but no exposures were observed. The initial formation of this meltwater channel probably occurred at the time of deposition of the Marlboro delta. A small outwash plain composed of pebbly gravel is located in Sec. 10, Tp. 53, R. 19 W5 and was deposited during the early stages of formation of the Sundance Creek meltwater channel. Larger outwash plains in the map-area are associated with the "headwaters" of meltwater channels in the southern part of the area.

Good examples of outwash gravel are illustrated in Plates 22 and 23.

Glaciolacustrine Deposits

General Remarks

Glaciolacustrine deposits include lacustrine clay, silt and sand, deltaic sand and pebbly sand. Deltaic deposits are included in this section because they form an important part of lacustrine basin sedimentation.

Glaciolacustrine sediments deposited in glacial lakes form the most common surficial material in the Edson Lowland. Important glaciolacustrine deposits also occur in other parts of the area (Figures 2 and 3), but since the deposits in the Edson Lowland are best known and most important economically, these will be described as a representative example.

Glaciolacustrine Sediments of the Edson Lowland

(1) Definition - Glaciolacustrine deposits are widespread in the Edson Lowland. The deposits are best exposed in SW 1/4 Sec. 20, Tp. 53, R. 16 W5 where 30.5 feet were measured (Section No. 262, Unit Nos. 4, 5, 6). The sediments range in thickness since the deposits partially mask irregular topography of the lowland; glaciolacustrine sediments are 40 feet thick in the McLeod River Section (Section No. 269, Unit Nos. 2, 3, 4, 5) but an average thickness of approximately 20 feet may be expected.

(2) Lithology - At section 262, two clay units are present between which is a very fine-grained sand unit. However, sand is most commonly developed in the lower part of the glaciolacustrine sediments at other localities. Localities at which sand forms the dominant surficial deposit are considered under the following section on deltaic deposits.

The most common lithology of the glaciolacustrine sediments forming the surface deposit is silty clay which is very calcareous in some places. The clay is everywhere at least two feet thick and is characterized by bands which may be varves (Plate 19). Up to 30 of these bands have been counted; they are composed of a dark grey unit, 3 to 5 mm. thick alternating with light grey units 1 to 3 mm. thick.

(3) Stratigraphic Relationships - The elevation of the contact between the glaciolacustrine sediments and adjacent topography ranges from 3200 feet in the western part of the Edson Lowland to 3000 feet near the eastern margin of the area on Highway 16. Only one beach deposit was located (Plate 24), so delineation of former shorelines was not possible. Most of the glaciolacustrine sediments are correlative to the Marlboro delta. Various levels of possible forerunners of the lake in the Edson Lowland, formed during retreat of the ice, occur in the southern part of the area (Figure 3). These deposits have not been studied in any detail.

(4) Origin - The scarcity of shorelines is partly the result of the transgressive nature of the glaciolacustrine sediments. This is illustrated by overlap of clay covering up the one known beach deposit (Plate 24), by the occurrence of residual pebbles eroded out of till upon initial transgression of glacial lake water (Plates 13 and 14) and by the stratigraphic sequence (Section No. 262, 265, 278). The coarser deposits in the lower part of the glaciolacustrine sediments are due to the initial influx of water which began to fill the basins between the retreating Continental ice on the east and the Cordilleran ice or the rise of land on the west. As more and more water accumulated, the lake rose in level to an elevation of approximately 3200 feet (this is the elevation of the Marlboro delta). The maximum elevation of the lake in the Edson Lowland may have been reached slowly but perhaps existed only a relatively short time. Continental

and Cordilleran ice then melted back and lacustrine sediment at an elevation of around 3000 feet was deposited in parts of the eastern part of the Edson Lowland.

Deltaic Deposits

One example of a deltaic deposit is the Marlboro delta which occupies an extensive area in the vicinity of Tp. 53, R. 19 and is the main source of sand for the Edson dune field. Large-scale, high angle, planar cross-strata consisting of pebbly sand are well exposed at several localities (Plates 25 and 26). Other stratigraphic units of this deltaic complex are given in Section No. 232. The cross-strata indicate current directions ranging from northeast, south, to southwest. The delta represents deposition from meltwater flowing from the Marlboro glacier into the glacial lake in the Edson Lowland during initial stages of glacier retreat. Some other poorly exposed deltaic sand deposits in the area are located in Tp. 50, R. 19; Sec. 18, Tp. 54, R. 18; and Sec. 7, Tp. 53, R. 18.

Nonglacial Recent Deposits

General Remarks

Deposits which are nonglacial in origin and Recent in age include aeolian, alluvial, colluvial and organic deposits. A brief description of these units is given.

Aeolian Deposits

Active and inactive aeolian sand deposits occur within the area, the latter being by far the more common.

(1) Active Aeolian Deposits - Aeolian activity is occurring at the present time along the east shore of Brule Lake. Sand and silt is deposited near shore while the Athabasca River is in flood. When the water recedes these deposits are subject to erosion by the

prevailing wind blowing eastward across Brule Lake. The main landforms being formed are elongate blowouts (Plate 27) and parabolic dunes. Sedimentary structures that may be observed on the surface of the dunes and blowouts include ripple marks, lag pebble deposits and bedding. Very fine-grained sand is the most common grain size being transported but silt and coarser sand sizes are also common. It is not known how far east aeolian material is being deposited; however, most of the timber stands in this general vicinity are very difficult to cut with power saws because the trees have incorporated windblown sand as they have grown.

The active sand dune area of Brule Lake may be due in part to the removal of vegetation from pre-existing stabilized dunes during construction of the first railroad in the area. The Grand Trunk Pacific Railway was built through the locality in 1910 (MacGregor, 1962); this must have aided aeolian erosion but certainly did not initiate it, since much older dunes have been recognized in this area.

(a) Dune Fields - Two prominent dune fields are present in the eastern part of the area; one is the Edson dune field and the other is the Rosevear dune field (Figures 2 and 3). Both dune fields consist dominantly of very fine to fine-grained sand which forms U-shaped dunes; some shallow blowouts and small sand shadows (Schultz and Cleaves 1955, p. 192) are also present. The sand of the Edson dune field was derived from the Marlboro delta but flood plain deposits of the McLeod River probably contributed some of the sand. The Rosevear dune field was derived from outwash or alluvial flood plain deposits related to the initial high level flow of water along the course of the pre-existing McLeod River; such

a stream would have been carrying considerable amounts of sand derived from the Marlboro delta complex. There are presently no adequate sand sources in the glacial or alluvial deposits in the general vicinity to explain the development of the Rosevear dune field.

Both dune fields are stable due to a heavy growth of vegetation. Other fields of stabilized dunes are found throughout the area, and the sand was derived most commonly from glacial outwash (Figures 2 and 3).

(b) **Bedded Sand** - Aeolian silty sand occurs in thick, well bedded units on the east side of Brule Lake whereas it is present mainly in the form of sand shadows around Hinton. The deposits are up to 200 feet thick in the vicinity of Brule Lake and thin towards the east. Bedding is defined by layers of charcoal-rich sand and in some places by laminations (Plates 7 and 28). The sand is medium to dark brown in colour and has been found up to an elevation of about 4,000 feet (Julian Dumanski, personal communications, 1967) within the Athabasca Benchland as far east as Pedley.

In the vicinity of Pedley and Hinton aeolian sand, silt and silty sand, included in the bedded sand unit, occurs in scattered patches as sand shadows usually in hollows of the ground surface in the lee of topographic highs and ranges from one to three feet in thickness. This sand overlies the Hinton terraces and the Obed till.

Alluvial Deposits

Alluvium occurs along small streams and rivers in the area as bars, low terraces and flood plain deposits. These sediments are composed of gravel with rare

sand beds, sand with rare gravel beds or interbedded sand and gravel beds. Silty, very fine-grained sand commonly overlies gravel in low alluvial terraces. Alluvial fans consist dominantly of coarse angular to subangular gravel mainly of local bedrock composition.

Colluvial Deposits

Colluvium in the area consists mainly of soil creep material, mixed weathered bedrock and till. In Figures 2 and 3 this unit also includes local patches of bare bedrock.

Organic Deposits

Organic deposits occur in most low-lying poorly drained parts of the area, but not all of these deposits have been outlined on the geologic maps. Peat is the dominant deposit which averages three to four feet in thickness but may be up to thirty feet thick in places as shown by seismic shot-hole drilling records.

AGE AND CORRELATION

General Remarks

As a result of field mapping and stratigraphic studies, relative ages and correlations have been established for many of the surficial deposits found in the Edson-Hinton area.

A few radiocarbon dates have been obtained from Recent deposits in the area and some age determinations north of the Edson-Hinton area are available. Since geochronologic information is incomplete, correlation with other areas is highly speculative at this time. However, the sequence of glacial events in the area is tentatively correlated in general with Rocky Mountain stratigraphy (Richmond, 1965) and that of the midcontinent area (Frye and Willman, 1960) in the United States.

Pleistocene-Tertiary Gravel

The oldest surficial deposits in the area are the Tableland, Lowland and Buried Valley gravel units.

The oldest unit is the Tableland gravel which is considered to be Tertiary in age by Russell (1965, p. 49).

Topographically the Tableland gravel can be generally correlated with the Swan Hills (Allan, 1919). Vonhof (in G.S.C., Report of Activities, 1967, p. 119) has placed the sand and gravel near Mayberne Fire Tower into a lithological province referred to as the Swan Hills Province. According to Vonhof, the main characteristic of this province is that the gravel component in these deposits is composed of 95 per cent

or more of quartzite.

The Lowland gravel is much younger than the Tableland gravel but is older than the Buried Valley gravel and the glacial deposits in the area, and is tentatively referred to the Early Pleistocene. Correlation is not attempted at this time.

The Buried Valley gravel was deposited after the Lowland gravel and predates known glacial deposits. It may be Sangamon in age since the gravel underlies tills considered to be Wisconsin in age, but there may be more than one system of buried valleys as mentioned under the section on physiography, therefore, correlation or even a general age designation on the basis of the present work is not possible.

Pleistocene Deposits

General Remarks

All glacial deposits are believed to be Wisconsin in age apart from the inferred "Early" Cordilleran advance which may be older than Wisconsin. Since there are no age dates available for the deposits, only a tentative stratigraphic sequence (Table 6) is presented on the basis of lithology, geomorphology and stratigraphy as has been discussed in detail under the section on stratigraphy of surficial deposits.

A diagrammatic cross-section showing some of the stratigraphic relationships of the principal drift and other surficial deposits in the area is given in Figure 14 (in pocket) and should be referred to in conjunction with Table 6.

Table 6 - Correlation Chart, Edson-Hinton Area

GLACIAL RETREAT	GLACIAL ADVANCE	NAME OF GLACIER		REPRESENTATIVE STRATIGRAPHIC UNITS
		CORDILLERAN	CONTINENTAL	
6/5				Outwash
	5	Drystone Creek	Not present	Drystone Creek till
5/4				Hinton terraces
	4	Obed	Not present	Obed till
4/3				Pedley, Plante Creek and Lake Edson sedi- ments, Marlboro delta
	3	Marlboro	Edson	Marlboro, Raven Creek, Mixed, Edson and Mayberne tills
3/2				Marsh Creek outwash
	2	? valley or piedmont	Marsh Creek	Marsh Creek till
2/1				Not observed
	1	"Early" Cordilleran	Not present?	Not observed

Relative Ages and Correlation in the Edson-Hinton Area

Stratigraphic units and other evidence indicate possibly five ice advances and five ice retreats in the area. Correlation of these units and their relative ages is based mainly upon field mapping relationships and the law of superposition.

The oldest advance is inferred by the evidence for the "Early" Cordilleran glaciation. A period of at least partial glacial retreat after the advance of the "Early"

Cordilleran ice is assumed, but stratigraphic units representing these events have not been discovered.

The oldest Continental deposit in the area is the Marsh Creek till. The presence of Canadian Shield erratics in the Raven Creek till, suggests that the Marsh Creek till probably lies below the Raven Creek till in the southern part of the area. An equivalent Cordilleran unit has not been observed but it is likely that one was present.

Marsh Creek outwash overlies Marsh Creek till and lies below Marlboro till at the type section on Oldman Creek; equivalent sediments have not been observed elsewhere.

The Marlboro and Raven Creek tills of Cordilleran source and the Edson and Mayberne tills of Continental source post-date Marsh Creek outwash; these units all occupy the same stratigraphic position as shown by field mapping and subsequent laboratory work, and are considered time equivalent. The Mixed till represents the deposits laid down by the mixed part of these Continental and Cordilleran glaciers where they joined and correlates with the Edson till towards the east and with the Raven Creek till towards the west.

Since the Emerson Lakes esker complex occurs beyond the limit of Obed till and at an elevation (3400 feet) above that of the terminal part of the Obed glacier (3300 feet), it is considered to be partly equivalent to the Marlboro till. This esker complex represents the initial deposits formed upon retreat of the Marlboro glacier and probably was deposited just before the Marlboro delta. The Marlboro delta in turn is believed to correlate with the lower part of the glaciolacustrine sediments of the Edson Lowland.

The Pedley sediments and the Plante Creek sediments are probably time equivalent since both units overlie Marlboro till and underlie Obed till within the Athabasca Benchland and both record similar conditions of deposition. Partly correlative deposits may be present in the upper part of the glaciolacustrine sediments of the Edson Lowland. Both the Pedley and Plante Creek sediments are believed to post-date the Marlboro deltaic deposits.

Obed till rests upon the Pedley sediments, the Plante Creek sediments and the Marlboro delta at a number of localities in the Athabasca Benchland and at one locality in the Edson Benchland. It is possible that the Obed till is partly equivalent to the upper part of the glaciolacustrine sediments of the Edson Lowland but firm evidence of this is lacking.

Outwash deposits of the Hinton Terraces rest disconformably on Obed till. These gravels are correlated in general with the pitted outwash of Jarvis Lake Valley and the Maskuta Creek kame moraine since all of these sediments were deposited during the time of retreat of the Obed glacier.

The Drystone Creek till has been found in several valleys along the mountain front (Figure 2), but it is not known definitely whether or not this advance was synchronous with the Obed advance. Tentatively, however, the Drystone Creek till is considered to post-date the Obed till since outwash deposits related to Drystone Creek till near the type section rest on an eroded surface of the Obed till along the valley of Drystone Creek.

Minimum Age of Retreat of Edson Glacier

A radiocarbon date of $12,190 \pm 350$ years B.P. which may provide a minimum date of the retreat of Continental ice (Edson glacier) from the area, has been supplied to the writer by D. St. Onge (personal communication, 1966). The date is on inorganic carbonate from "fresh-water shells in cross-bedded sands from a road cut

in South Kaybob oilfields, Alberta L.S.D. 14, Sec. 12, Tp . 62, R. 21, W5 (54° 21' N. lat., 117° 01' W. long.) at alt. ca. 2700 ft." St. Onge stated that the deltaic sands enclosing the shells were deposited by Little Smoky River into Glacial Lake Rycroft. Until confirmed by other dates this date must be regarded as tentative.

The outwash sand of the Wildhay River Section, (Section No. 273, Units 2 and 5) may correlate generally with the deltaic beds on the Little Smoky River, which is 25 miles to the north; however, the outwash on the Wildhay River is at an elevation of approximately 3,300 feet, 600 feet higher than the deltaic sand on the Smoky River. Nevertheless, the date of $12,190 \pm 350$ years B.P. tentatively suggests that the Edson glacier had retreated by this time, which in turn means that the Marlboro glacier retreated prior to this date also.

St. Onge (1968, p. 186 and 187) has recently provided additional radiocarbon dates of organic remains collected from two separate deposits of lacustrine origin north of the Edson-Hinton area. The dates are $10,900 \pm 160$ (G.S.C.-859) years B.P. and $10,000 \pm 170$ (G.S.C.-861) years B.P. The significance of these dates for the present area is that they present further evidence that the Continental or Edson glacier had receded from the Edson-Hinton area prior to approximately 10,000 years before the present.

Recent Deposits

The majority of Recent deposits can be differentiated in relative age by geomorphology, however, this has not been attempted in this study except for the general designation of inactive and active sand dunes, the latter being the youngest. Most of the established dune fields are arbitrarily assigned to the Altithermal ---- 4,000 to 6,500 years B.P. (Richmond, 1965, p. 227). Isolated radiocarbon dates of two Recent deposits, aeolian bedded sand and marl, are discussed in the following

paragraphs along with an occurrence of terrestrial gastropods in stabilized sand dunes.

Age and Fauna of Marl at Marlboro

Fresh water pelecypods, gastropods and ostracods were collected from marl within four feet of the ground surface (Lsd. 14, Sec. 6, Tp. 53, R. 19, W5) at Marlboro. The marl is extremely fine grained and contains up to 10 per cent fossils. It rests upon an eroded surface of the Marlboro delta and lies beneath muskeg in some places. The fauna identified by Dr. R. Green, Research Council of Alberta, includes the following forms:

Ostracods	Gastropods	Pelecypods
<u>Cyclocypris serena</u> (Koch)	<u>Gyraulus</u> sp.	<u>Pisidium</u> sp.
<u>Cyclocypris ovum</u> (Jurine)	<u>Helisoma</u> sp.	
<u>Cypridopsis vidua</u> (Mueller)	<u>Physa</u> sp.	
<u>Candona crogmaniana</u> Turner	<u>Stagnicola</u> sp.	
<u>Candona distincta</u> Furtos		
<u>Candona rostrata</u> Brady and Norman		
<u>Notodromas monacha</u> (Mueller)		

The environment of the fauna was that of a pond or littoral zone of a lake of warm shallow, permanent-water conditions, and all elements of the fauna live in present-day Alberta water bodies.

The same marl sample was submitted to the Geological Survey of Canada for radiocarbon dating and the result was an age of $8,830 \pm 150$ years B.P. (G.S.C. 768).

Rubin et. al. (1963, p. 87) in a general study of the reliability of radiocarbon dates presented information which suggested that dates on carbonates such as the marl of the present study may be too old by about 1,000 years. The date gives a minimum age for the Marlboro glacier as the marl overlies outwash deposited by this glacier. More specifically, the date represents a minimum age of retreat of the younger Obed glacier because the locality at which the marl occurs could not have escaped the effect of cold meltwater coming from Obed ice under which conditions the marl would not have been deposited.

Age of Aeolian Bedded Sand

It may be possible to establish at least a local post-glacial chronology by studying the aeolian deposits in the vicinity of Brule Lake since one sample of charcoal in one of the beds in the bedded sand (SW 1/4 Sec. 24, Tp. 49, R. 27, W5) has been dated by the radiocarbon method at $2,190 \pm 170$ years B.P. (Isotopes, Inc., I-2614). This bed is not the lowest in the sequence. Another date from the same kind of deposit in SE 1/4 Sec. 25, Tp. 50, R. 27, W5 (Plate 23) gave a radiocarbon age of $1,300 \pm 95$ years B.P. (Isotopes, Inc., I-2613).

Terrestrial Gastropods in Stabilized Dunes

Several species of gastropods occur in aeolian sand of a stabilized dune field on the east bank of Maskuta Creek (NE 1/4 Sec. 5, Tp. 31, R. 25, W5) and have been identified by Dr. R. Green, Research Council of Alberta. The gastropods include Vallonia gracilicosta Reinhardt, Discus cronkhitei (Newcomb), and Discus shimeki (Pilsbry). All are found today in Alberta, and all have a wide geographic range.

Correlation of Glacial Deposits with Other Areas

The surface drifts in the area are tentatively assumed to be of "Classical" Wisconsin age, since Continental drifts only of Wisconsin age are known in Alberta (Bayrock, 1965). The Marlboro, Obed and Drystone Creek tills, all of Cordilleran source, may correlate (Table 9) with the stades of the Pinedale Glaciation of Richmond (1965). The Edson and Mayberne tills, of Continental source probably represent the Woodfordian Substage of Frye and Willman (1960) since these tills may be older than approximately 12,000 or 10,000 years B.P. (St. Onge, 1968, 1967a).

The Marsh Creek till of Continental source, recognized only in the sub-surface at one locality, predates all of the surface drifts and may be correlative to the Altonian Substage of Frye and Willman (1960). The Cordilleran glacier which is inferred to have been present when the Marsh Creek advance took place may be assigned to the Bull Lake Glaciation of Richmond (1965).

Correlation of the suspected "Early" Cordilleran till is not attempted in this report.

Edson-Hinton Area (This Report)		Rocky Mountains - U.S.A. After Richmond (1965)		Midcontinent Region After Frye and Willman (1960)	Approx. Age B.P.	
CORDILLERAN	CONTINENTAL					
Drystone Creek Advance Hinton Terrace Grovel Obed Advance Pedley Sediments Morlboro Advance	Edson Advance Marsh Creek Outwash Marsh Creek Advance	Neoglaciation	Gannett Peak Stade	Recent	- 800	
			Interstade		- 900	
			Temple Lake Stade		- 4,000 - 5,000 - 6,500	
		Altithermal	Interval	Volderon Substage	Wisconsinian Stage	- 10,000 - 11,000 - 12,000
			Late Stade			
			Interstade			
		Pinedale	Middle Stade	Twocreekan Substage	Woodfordian Substage	Several Advances
			Interstade			
			Early Stade			
		Glaciation	Interstade	Farmdolian Substage	Altonian Substage	- 22,000 - 25,000 - 28,000 - 32,000
Early Stade						
Interstade						
Bull Lake	Interglaciation	Late	2nd Episode	- 45,000		
		Stade			Nonglacial Interval	
		1st Episode				
	Glaciation	Nonglacial Interval	Early Stade	Sangamonian Stage	50,000 to 70,000 (estimate)	

TABLE 9 Tentative Correlation Chart of the Wisconsin Deposits of the Edson-Hinton Area and the Rocky Mountain(U.S.A.) and Midcontinent Regions.

GLACIAL HISTORY

General Remarks

An impressive but surprisingly straight forward history of glacial events is recorded in the drift of the Edson-Hinton area. Although the earliest glacial history is nearly obscure, the later history can be broadly interpreted with confidence.

The surficial geology maps, Figures 2 and 3, should be referred to while one reads this section on the glacial history. A topographic map is included in Figure 11 and a sketch map showing some features related to the discussion on glacial history is given in Figure 19. All of the important features discussed in the text can be readily observed on these maps. Diagrammatic representation of each of the glacial history stages is not attempted in this report since there is poor control in the foothills and mountainous area.

Summary of Glacial History

The first glacial event inferred from mapping is a widespread Cordilleran ice advance which possibly reached an elevation of 4,000 feet in the Mayberne Tableland. It is not known whether Jarvis Lake Valley, interpreted to be glacial in origin, was formed before or after this early ice advance.

The "Early" Cordilleran ice may have receded to the west beyond the area and then advanced again or may have only receded a short distance and remained occupying the area west of a line connecting Wildhay River, Marsh Creek, Marlboro, Raven Creek, and Lund Creek. Nevertheless the Marsh Creek glacier of Continental source advanced from a general northerly direction into the Edson-Hinton area at least as far as the above mentioned line at this time, and may have come into contact with

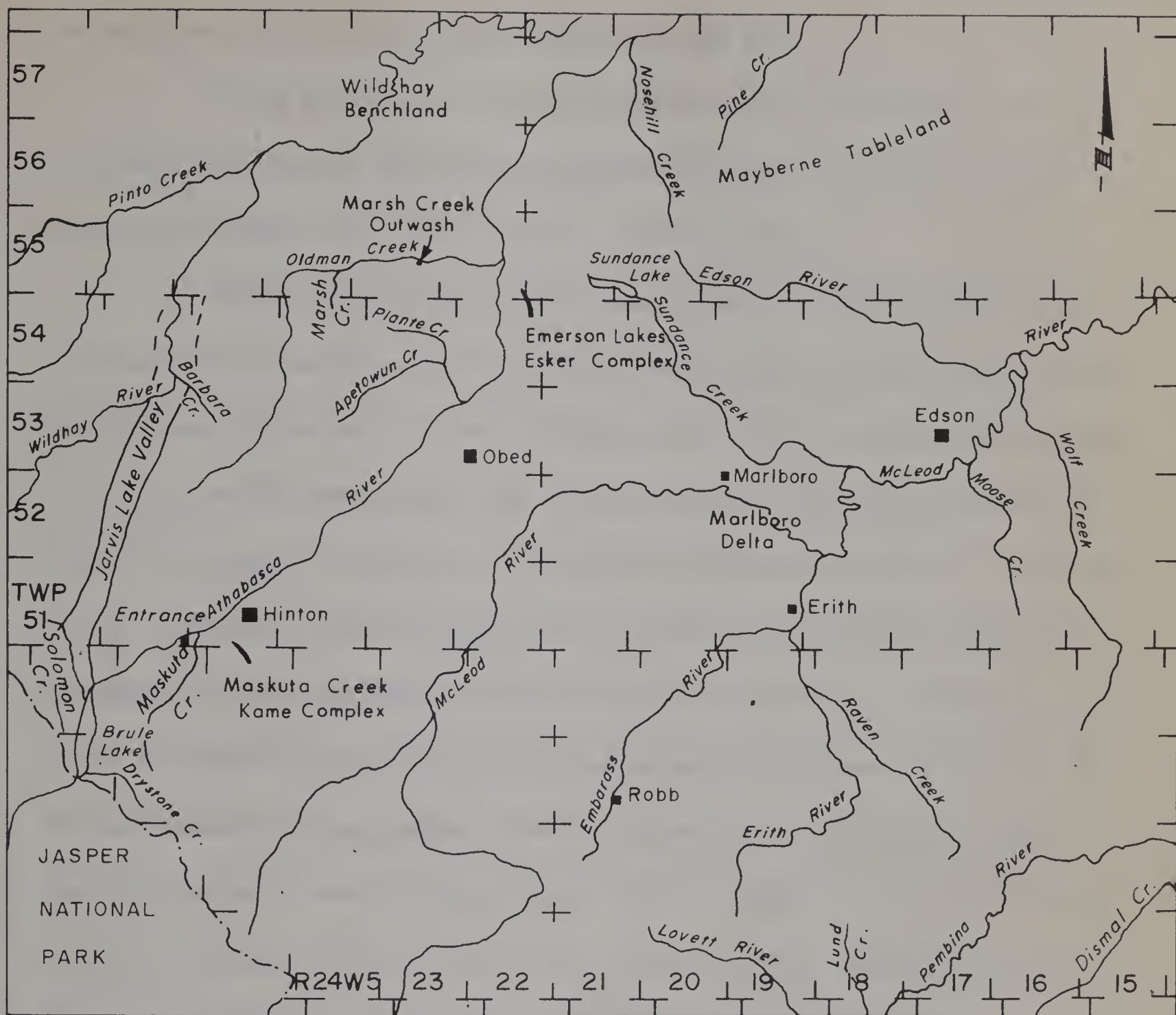


FIGURE 19

MAP SHOWING LOCATION OF SOME FEATURES
RELATED TO THE GLACIAL HISTORY

a piedmont or valley glacier(s) of Cordilleran ice. The Marsh Creek glacier represents the maximum extent of Continental ice advance in the area.

During the recession of the Marsh Creek glacier of Continental source, the Marsh Creek outwash sediments were deposited; however, Cordilleran outwash that can be assigned to the same interval has not been observed.

The next major glacial activity was the advance of both Cordilleran and Continental ice referred to respectively as the Marlboro glacier and the Edson glacier. The Marlboro glacier spread out over tablelands and foothills, overriding Marsh Creek till, and came into direct contact with the Edson glacier. The dashed line shown in Figure 16 represents the contact zone between tills of these two glaciers. The northern part of the Marlboro glacier probably became stagnant but the southern part flowed in a southeasterly direction between the Continental ice and the Rocky Mountains. Most of the Continental ice was probably deflected towards the southeast at this time. The two southeasterly flowing glaciers, therefore, joined and in the southeastern part of the area produced a zone of mixing represented by the Mixed till. Very little mixing of the two glaciers is evident in other parts of the area. If the Marlboro glacier was the carrier of quartzite erratics of the Foothills Erratics Train, which seems very probable, the two glaciers flowed to the southeast for a great distance, far enough for both of the glaciers to flow 350 miles to reach beyond the International Boundary. The Marlboro glacier was the maximum advance of Cordilleran ice in the area, and it is believed to have been derived from an accumulation area of great extent.

Meanwhile, according to this interpretation the northern lobe of the Marlboro glacier remained stagnant and in contact with the Continental ice. This part of the Marlboro glacier is the one which carried most of the erratics of the

Athabasca Valley Erratics Train from west of the Rocky Mountain Trench. The erratics train may therefore have been transported during the initial advance of the Marlboro glacier and may even be older than much of the Foothills Erratics Train (Appendix B).

Retreat of the Marlboro glacier in a northwesterly direction is marked by a system of well-defined ice-marginal channels in the southeastern part of the area. One of these channels is occupied by Dismal Creek, another by Pembina River and others are shown in Figures 2 and 3. Associated with these features are a number of outwash plains, kame moraines, glaciolacustrine sedimentary units and associated spillways. Meltwater was presumably ponded in local depressions and as the ice melted the spillways rapidly drained the lakes that had formed. Lacustrine deposits near the headwaters of Wolf Creek reach an elevation of 3,450 feet. To the west, however, between the foothills and the Marlboro glacier to the east, glaciolacustrine sediments occur up to an elevation of 3,800 feet. At a later time after the Marlboro and Edson glaciers had melted in this part of the area, these lakes may have eventually drained to lower elevations in the Edson Lowland. In the northern part of the area, near Wildhay River, the terminal moraine of the Marlboro glacier is marked by several kame complexes, a series of ice-marginal meltwater channels, lobate end moraine and other features representing ice-disintegration.

The initial glaciolacustrine deposits of the Edson Lowland in the eastern part of the area began to accumulate when the Cordilleran and Continental ice had receded to the north to about Township 53. The Emerson Lakes esker complex and the Marlboro delta began to form while the Marlboro and Edson glaciers were still in

contact. Meltwater from the Emerson Lakes esker complex spilled down Sundance Creek in an ice-marginal channel; probably some escaped to the north, but Continental ice was likely still present just to the north partially blocking drainage. This is supported by the abundant outwash (possibly deltaic) sand of the Wildhay Benchland in the vicinity of Tp. 57, R. 22 and 23 (see Wildhay River Section, Section No. 273, Units 2 and 5). The meltwater which formed the Marlboro delta (elevation 3200 feet), as well as the water flowing down Sundance Creek, supplied sediment to the glacial lake which reached its maximum elevation of 3200 feet in the Edson Lowland at this time.

During retreat of the Marlboro glacier west to the locality of Obed, a series of small, south flowing ice-marginal channels was formed (Figure 8). Some of this meltwater brought about partial dissection of part of the Marlboro delta. During the same time water still poured out of the area of the Emerson Lakes esker complex. Some of this water escaped southward down the Sundance Creek meltwater channel, which was being deeply eroded, and served to dissect another part of the Marlboro delta. A glacial lake, which was probably at an elevation of between 3100 and 3000 feet, received this water and also probably received water from the Continental ice. This ice was east of the area by this time (possibly prior to $12,190 \pm 350$ years B.P.), but still acted as a barrier forming the eastern shore of the glacial lake.

The Marlboro glacier continued to recede to the west at least as far as Brule Lake and may have stayed there for a considerable length of time. In the Athabasca Benchland, the Pedley sediments were deposited and in Plante Creek valley the Plante Creek sediments were laid down. The interbedded and discontinuous

character of these fluvial and lacustrine units of the Pedley sediments indicate that the Athabasca River was still very poorly developed, which in turn suggests the presence of Continental ice not too far north of the area. Sediments probably equivalent to the Pedley sediments, and recording similar conditions, occur in the Wildhay Benchland in Tp. 55, and 56 and R. 25.

The Obed glacier is considered to have been composed partly of ice left over from the Marlboro glacier (as indicated by the Athabasca Valley Erratics Train), and advanced eastward and northward to the present mapped limits of the Obed till. It overrode Pedley sediments and Marlboro till in the Athabasca Benchland and part of the Marlboro delta sediments in the eastern part of the area. The terminal part of the Obed glacier reached elevations of 3,350 feet in Sec. 35, Tp. 52, R. 20 W5, 3,500 feet in Sec. 30, Tp. 53, R. 21 (photogeologic interpretation) and possibly 3,500 feet in Tp. 54, R. 22. In the vicinity of Entrance, the glacier stood at an elevation of approximately 4,300 feet, 1,000 feet above the present Athabasca River.

During the initial melting of the Obed glacier lacustrine sediments were laid down in Plante and Apetowun Creek valleys and an esker complex developed in Tp. 54, R. 22. The present course of the Athabasca River was established at this time.

The next important stage was a still-stand of the Obed glacier at Maskuta Creek during which the Maskuta Creek kame complex and the Upper Hinton Terrace were formed. Meltwater flowed down both the Athabasca River valley and the Jarvis Lake Valley at this time. The pitted outwash in Jarvis Lake Valley was formed along with most of the outwash to the north of Jarvis Lake. The ice front then retreated to

between Brule Lake and Entrance at which time the lower Hinton Terrace was formed, and the glaciolacustrine and glaciofluvial material was deposited in the terraces on the west and east flanks of Jarvis Lake Valley. A block of ice which filled the valley may very well have been present in the area now occupied by Solomon Creek. Further wasting to the park boundary allowed most of the water to flow down the Athabasca River. This increased flow probably dissected the lower Hinton Terrace, formed the bedrock buttressed terrace in the northwest part of Tp. 50, R. 26, deposited the outwash occurring all around Brule Lake and in the bottom of Solomon Creek valley and firmly established the present course of the Athabasca River. Meanwhile, retreat of the ice in the Maskuta Creek valley was marked by ice-disintegration; very little meltwater flowed down this prominent topographic depression.

Drystone Creek glaciers in the form of local alpine glaciers advanced down valleys of the Front Ranges but probably did not extend into the main valleys. The advance was short-lived, and upon retreat of the ice, minor outwash deposits were formed.

ECONOMIC GEOLOGY OF SURFICIAL DEPOSITS

Introduction

Surficial deposits form an extremely important part of the economic environment of any area and especially the Edson-Hinton area. Soils developed in surficial material form the basis of agricultural development and also play a major role in the forest productivity capacity of the land, critically important in this area. The most exploited and promising sources of water for human and industrial consumption are groundwater aquifers in surficial deposits, and the granular deposits that are so abundant in the area form one of the leading industries in Canada. Also, the location of dam sites, construction materials, erosion hazards, and town sites are important economic aspects of the engineering geology of surficial deposits which must be considered in the orderly development of land. The following account is therefore included in this study as an integral part of the surficial geology of the area.

Agricultural Lands

The agricultural potential of the area is presently being evaluated in considerable detail by the Soil Survey, Research Council of Alberta. Pending this evaluation it is suggested here that some parts of the area may be drained in the future to provide arable land. One example of this is in the area of Plante and Apetowun Creeks, where extensive meadows occur but which are presently very wet. The gentle slope of the land is towards the valleys so that drainage may be feasible. Also large parts of the Edson Lowland and Pembina-McLeod Benchland do not have as much organic material developed as is generally thought.

Forest Productivity

The map-area is part of an extensive pulpwood lease area which is under large scale development by North Western Pulp and Power Ltd. A tentative method of estimating productive capacity of a forest land has been formulated over the last five or six years by Mr. P. Gimbarzevsky (1965), formerly with the above company. The following general process of arriving at a classification of productive capacity of forest land represents a modified summary of Gimbarzevsky's work.

1. Division of the area into physiographic units characterized by landforms of similar geologic origin and composition, and by similar surface drainage, based on study of aerial photographs and topographic maps.
2. Delineation of broad units of surficial deposits within physiographic units on the basis of study of the aerial photographs, supported by field mapping and laboratory analyses of surficial deposits.
3. Division of surficial deposits into various production classes, I, II, III, IV, V, etc., based upon known volumes of pulpwood per acre at maturity age. This step necessarily involves detailed inventory of a type sample for each kind of surficial deposit and correlation to other similar geomorphic units throughout a given area.
4. Calculation of productive potential of various landforms projected throughout a given area.
5. On-site production inventory for re-growth potential which may be correlated with original classification of forest productivity and form a framework for reforestation programs.

By accurate identification and classification of landforms or geomorphic units, a rapid and efficient method for evaluating forest productivity is therefore available. This may be used for administration and the economic analysis of an area by government or may be used by pulp and lumber companies for production and cost control projections.

Groundwater Geology

General Remarks

The water supply for the town of Edson is derived from a Buried Valley gravel aquifer (Gabert and Roed, in press) and all campsites and parks in the area obtain water from aquifers in the surficial deposits. Numerous residents of farms and estates also derive groundwater for human and stock consumption from aquifers in surficial deposits. The principal aquifers are located in granular deposits of buried valleys, pitted outwash, deltas, terraces, interstadial sediments, alluvial and aeolian materials. The location of each is shown in Figures 2 and 3 and a diagrammatic representation of potential aquifers of the surficial deposits is shown in Figure 14.

Buried Valleys

Some buried valleys are shown in Figure 8. Aquifers in buried valleys are mainly gravel deposits which are covered by relatively impermeable till and underlain by bedrock. Water under a considerable hydraulic head may be encountered in some of the aquifers. Delineation of buried valleys in the southern part of the area is very difficult since there is little seismic shot-hole information. Landforms do not reveal

much information in regard to location of these buried valleys. Some buried valleys are up to 150 feet deep but the average depth is probably about 100 feet (Gabert and Roed, in press). Buried valleys with the greatest groundwater potential are the ones located beneath the Athabasca River, McLeod River and Jarvis Lake Valley. The buried valley beneath Jarvis Lake Valley is believed to offer the most potential as a source for very large quantities of groundwater.

Pitted Outwash

Significant quantities of groundwater should be available in pitted outwash deposits located in Jarvis Lake Valley within two hundred feet of the surface, but the extent of potential aquifers depends upon local stratigraphic relationships of the various units. Pitted outwash deposits commonly contain inclusions of till and interbeds of clay which may affect groundwater production.

Interstadial Sediments

The Pedley sediments in the Athabasca Benchland offer considerable potential for groundwater production. Numerous sand and gravel units occur within 100 feet of the surface and many may contain groundwater which would have a considerable hydraulic head.

Deltaic Sediments

Tongues of sand, pebbly sand and gravel of the Marlboro delta complex and other deltaic units extending into glaciolacustrine sediments (Figure 14) offer the potential of significant near-surface aquifers within 50 feet of the surface over a

considerable area in the Edson Lowland. This possibility is of special importance to rural inhabitants.

Terraces

Numerous outwash terraces are present in the area, examples of which are the Hinton terraces. Extensive near-surface groundwater aquifers may occur in sand and gravel deposits of these units especially where they are underlain by impermeable beds of till, Pedley sediments or bedrock.

Aeolian and Alluvial Deposits

Most of the aeolian and alluvial granular deposits in the area form potential near-surface groundwater aquifers.

Conclusion

Aquifers in surficial deposits of the area offer a variety of potential reservoirs for plentiful groundwater production in relation to the economic potential of the area. The groundwater reserves are essentially untapped.

Marl

The Marlboro Cement Company established a cement plant at Marlboro in 1912 to utilize local marl deposits, but these proved unsatisfactory and by 1917 the cement plant was receiving limestone from a quarry near Jasper (Goudge, 1946, G.S.C., 1913, Govett and Byrne, 1958).

The marl at Marlboro is at least four feet thick, and can be observed

to the east of the hamlet of Marlboro where it is overlain by organic material and underlain by sand and gravel of the Marlboro delta. It is very fossiliferous, containing gastropods, pelecypods and ostracods. The marl has been dated by the radiocarbon method at $8,830 \pm 150$ years B. P.

A chemical analysis of the marl gave a total of 92.24 per cent calcium carbonate, 3.63 per cent magnesium carbonate and 4.1 per cent organic and other material. The low calcium carbonate content is probably the main reason the marl was not developed further for the manufacture of cement.

The reserve of marl is not known but the deposit probably underlies a large part of the hamlet of Marlboro. A modest shallow auger drilling program would be sufficient to outline the extent of this deposit.

Recreational Geology

Recreational geology is defined as the interpretation of geologic phenomena for the pleasure of the general public. It includes preserving geologic features of the landscape which are of special historic and academic interest and in turn informing the public about these features. A commendable series of publications by Dr. David M. Baird of the Geological Survey of Canada may be cited as an example of this kind of geology; one of these publications is listed in the references (Baird, 1963).

A growing number of the general public is rapidly becoming more scientifically informed, and with the rise of general education comes the dutiful challenge to professional people of presenting facets of their scientific studies in such a way as to benefit and provide pleasure to the general public. The interest displayed by people on "the nature of things" may be due to a passing curiosity, a genuinely

deep concern, or it may be a recreation which gives them pleasure and provides a certain depth to their experiences. Interesting, unusual and spectacular geologic features are of interest to nearly everyone and especially to tourists who are usually touring because they want to relax, see something that is different and educational, and leave with lasting memories. It is therefore the duty of professionals to make sure that these people are presented with as many different geologic aspects of our culture and landscape as possible.

Some features which have potential application in the recreational geology of the area are briefly listed below:

1. The geologic significance of the following features should be presented: Athabasca Benchland and Tableland; glacial sculpturing of the mountains; Hinton terraces and associated erosional remnants of Obed till; Marlboro delta; Edson dune field; glaciolacustrine deposits of Edson Lowland; Tableland and Benchland gravel; Buried Valley groundwater reservoirs; contact zone between Continental and Cordilleran glaciers; Sundance Creek.
2. The following geologic features should be protected from destruction: Erosional remnants of Obed till within and about the town of Hinton; Marlboro deltaic deposits (Plate 25); pits and mounds in the pitted outwash around Jarvis Lake; eskers of the Emerson Lakes esker complex.
3. Potential areas of recreational development which are associated with distinctive geologic features include: East side of Brule Lake in the dune field; parts of the Hinton terraces; Sundance Lake, in a meltwater spillway; Emerson Lakes, in an esker complex; north part of the top of High Divide Ridge (viewpoint); Miller's Lake; Plante Creek valley.

Granular Deposits

Granular deposits are widespread in the Edson-Hinton area but most of the very large deposits, in excess of one million cubic yards, are restricted to extensive outwash gravel deposits found along valleys and terraces formed by melt-water. The Canadian National Railway has exploited the lower Hinton terrace gravel for many years for crushed ballast. Ballast for the new Alberta Resources Railroad is being derived from outwash gravel on the west side of Jarvis Lake Valley.

At Edson most of the pit-run gravel comes from outwash gravel whereas concrete aggregate is presently restricted to a comparatively coal-free source of alluvial gravel of the McLeod River. Sand from the Marlboro delta has been exploited extensively during the last three years as pit-run fill.

In the Mayberne Tableland discontinuous lenses of Tableland gravel are being processed and crushed for road aggregate but the gravels contain considerable amounts of clay and muscovite which severely hampers the washing and crushing process. In addition the gravel is extremely difficult to find since its stratigraphic form is not well understood and there are very few outcrops from which the unit can be studied.

Small patches of Lowland gravel have been developed for pit-run aggregate but these gravels do not form significant economic deposits since they are localized, of small extent and in most places overlain by excessive overburden.

Eskers and esker complexes are abundant in the area all of which, no matter how small, have been shown on the geologic map. Except for a very few eskers composed mainly of sand, most are composed of gravel and in many places the gravel

is very clean and well graded (poorly sorted) in general. Almost all of the eskers have remained undeveloped or undiscovered up until the present time which is surprising since a few are located right beside a railroad. The single esker in the Mayberne Tableland still remains untouched despite its location near a well-travelled road. Small kames have been developed locally for pit-run aggregate.

Rip-rap sources in surficial deposits, apart from bouldery gravel, which is rare in the area, would be confined to erratics in the stony Obed till. In some isolated areas, however, large angular erratics belonging to the Erratics Train, Foothills of Alberta, occur in abundance and could form commercial deposits of rip-rap. Detailed field surveys would be necessary to locate these deposits.

In conclusion, there is no scarcity of granular deposits in the Edson area. No attempt has been made to evaluate the deposits but the gross dollar value of all the various deposits of commercial grade would be very high.

Engineering Geology

"Engineering geology is that part of applied or economic geology that requires the application of discriminating geologic observation and reasoning to problems encountered in engineering practice" (Kiersch, 1955, p. 2).

Numerous aspects of the surficial geology of the area in some way affect engineering practice but it is not feasible to discuss all these here. Rather, some important generalizations are made in relation to major engineering projects such as dam construction. The sections on groundwater aquifers and granular deposits are equally applicable in this section. Most of the features may be expected in other glaciated parts of the Foothills in western Canada.

Geologic Foundation Conditions

Unconsolidated sediments in the major valleys of the area are extremely diverse. The Pedley sediments, for example, contain thick bands of clay, silt, sand and gravel throughout the Athabasca Benchland. The strength, compression, and porosity-permeability characteristics of these materials will vary considerably. These sediments may be very thick and offer considerable groundwater and settlement problems. The bedrock valley in which these sediments have been deposited has undergone considerable erosion throughout the Pleistocene so that undercuts formed by fluvial erosion in the bedrock which have been later filled with granular material may be expected. Such undercuts or reentrants (Alexander et al., 1967) have been found in bedrock at an elevation of 4,400 feet in Sec. 30, Tp. 53, R. 23 W5.

Buried valleys are very common in parts of the area and usually represent major groundwater aquifers. Two or three systems of buried valleys having different trends and gradients are known. In addition major valleys emerging from the mountains may be considerably overdeepened; this is believed to be the case with the Athabasca River valley and Jarvis Lake Valley.

Mass movement is not considered a major problem of the till in this area since most of the tills are quite sandy and stable along present river valleys. Some landslides are located where buried valleys are intersected by present streams, and others are located in the Edson till and the Drystone Creek till both of which are particularly unstable; glaciolacustrine clay is also unstable.

In many parts of the area, bedrock can be accurately delineated by photogeologic interpretation and the amount of overburden estimated. Bedrock scarps

which are covered with up to ten feet of surficial material have been mapped in Figures 2 and 3. Engineering geology problems related to the bedrock are not considered here.

It is important that engineering projects involving the surficial material to any great extent should be preceded by an investigation of the surficial deposits and related bedrock features along with a detailed study of the geologic history.

Conclusion

The economic aspect of the surficial geology of the area has been demonstrated to be extremely important in many ways. Considerable study along this line of endeavor is therefore desirable.

REFERENCES CITED

- Alexander, C. S., Price, L. W. and Vuk, U. M.
1967: Inlaid Modern Sediments in Pleistocene Terrace Alluvium, Southern Illinois, Bull. Geol. Soc. Am., Vol. 78, pp. 1037-1038.
- Allan, J. A.
1919: Geology of the Swan Hills in Lesser Slave Lake District, Alberta. Geol. Surv. Canada, Summ. Rept. 1918, pt. C, 11. 7-13.
- American Commission on Stratigraphic Nomenclature
1961: Code of Stratigraphic Nomenclature; Bull. Geol. Soc. Am., Vol. 45, No. 5, pp. 645-665.
- American Geological Institute
1966: Glossary of Geology and Related Sciences with Supplement; American Geological Institute, Washington, D.C., Second Edition, 325 pp., Supplement 72 pp.
- Antoniuk, S. A.
1954: A Mineralogic Study of the Saskatchewan Sands and Gravels; Department of Geology, Univ. Alberta, M.Sc. thesis, 63 pp.
- Baird, D. M.
1963: Jasper National Park, Behind the Mountains and Glaciers; Geol. Surv. Canada, Misc. Report No. 6.
- Bayrock, L. A.
1958: Glacial Geology, Alliance - Brownfield District, Alberta; Research Council of Alberta, Geological Division, Preliminary Report 57-2, 56 pp.

1962: Heavy Minerals in Till of Alberta; J. Alberta Soc. Pet. Geol., vol. 10, No. 4, pp. 171-184.

1965: Incomplete Continental Glacial Record in Alberta; International Association for Quarternary Research, VII International Congress, Abstract, p. 18.
- Bayrock, L. A. and Hughes, G. M.
1962: Surficial Geology of the Edmonton District, Alberta; Research Council of Alberta, Prelim. Report 62-6, 40 pp.

- Bostock, H. S.
1948: Physiography of the Canadian Cordilleran, with Special Reference to the Area North of the Fifty-Fifth Parallel; Geol. Surv., Canada, Memoir 247, 106 pp.
- Bouyoucos, G. J.
1951: Recalibration of the Hydrometer Method for Making Mechanical Analysis of Soils; Agronomy J., vol. 43, pp. 434-438.
- Campbell, R. B.
1966: Canoe River Map-area (83D); in Report of Activities; Geol. Surv. Can., Paper 66-1, p. 51.
- Christiansen, E. A.
1956: Glacial Geology of the Moose Mountain Area, Saskatchewan; Department of Mineral Resources, Report No. 21, 34 pp.
- Coleman, A. P.
1910: The Drift of Alberta and the Relations of the Cordilleran and Keewatin Ice Sheets; Trans. Roy. Soc. Can., 3rd ser., vol. 3, sec. 4, pp. 3-12.
- Davis, W. M.
1932: Piedmont Benchlands and Primarrumpfe; Bull. Geol. Soc. Amer., vol. 43, pp. 399-440.
- Dawson, G. M.
1890: On the Glaciation of the Northern Part of the Cordilleran with an Attempt to Correlate Events of the Glacial Period in the Cordilleran and Great Plains; Am. Geol., vol. 6, pp. 153-162.
- Dowling, D. B.
1909: Coal Fields South of the Grand Trunk Pacific Railway, in the Foothills of the Rocky Mountains, Alberta; Geol. Surv., Canada, Summ. Rept. pp. 139-151.
1910: Coal Fields of Jasper Park, Alberta; Geol. Surv., Canada, Summ. Rept. 1910, pp. 150-168.

Dreimanis, Aleksis,

1962: Quantitative Gasometric Determination of Calcite and Dolomite by Using Chittick Apparatus; J. Sed. Pet., vol. 32, No. 3, pp. 520-529.

Flint, R. F.

1957: Glacial and Pleistocene Geology; New York, John Wiley and Sons, Inc., London, 553 pp.

Frye, J. C. and Willman, H. B.

1960: Classification of the Wisconsin Stage in the Lake Michigan Glacial Lobe; Ill. Geol. Surv., Circ. 285, 16 pp.

Gabert, G. and Roed, M. A.

. Buried Valleys in the Vicinity of Edson, Alberta; Research Council of Alberta, Prelim. Rept., in press.

Geological Association of Canada

1958: Glacial Map of Canada; Geol. Assoc. Canada, Toronto, map.

Geological Society of America

1963: Rock-Color Chart, Prepared by the Rock-Color Chart Committee; Geological Society of America, New York, N. Y.

Geological Survey of Canada

1967: Report of Activities, Part A; May to October, 1966; Geol. Surv. Canada, Paper 67-1, Part A, 221 pp.

Geological Survey of Canada

1913: Toronto to Victoria and return via Canadian Pacific, Grand Trunk Pacific and National Transcontinental Railways;

Map q: Route map between Edmonton and Edson, Alberta, scale 1 inch to 15 miles.

Map r: Route map between Edson, Alberta and Tete Jaune, B. C., scale 1 inch to 1 mile.

Gimbarzevsky, Philip

1965: Physiography, Surficial Deposits and Tentative Productivity of North Western Pulp and Power Ltd. Lease Area; Unpubl., 27 pp.

1966: Land Inventory Interpretation, Photogrammetric Engineering, November, pp. 967-976.

Goudge, M. F.

- 1946: Limestone of Canada, Their Occurrence and Characteristics;
Canada Mines Br., Publ. No. 811, pp.

Govett, G.J.S. and Byrne, P.J.S.

- 1958: Industrial Minerals of Alberta; Research Council of Alberta,
Prelim. Rept. 58-2,; 112 pp.

Gravenor, C. P.

- 1953: The Origin of Drumlins;
Am. J. Sci., vol. 251, pp. 674-681.
- 1955: The Origin and Significance of Prairie Mounds;
Am. J. Sci., vol. 253, pp. 475-481.

Gravenor, C. P. and Kupsch, W. O.

- 1959: Ice-disintegration Features in Western Canada; J. Geol.,
Vol. 67, No. 1, pp. 48-64.

Hector, J.

- 1863: Geological report: The journals... relative to the exploration
by Cpt. John Palliser of that portion of Br. North America ...
during the years of 1857, 1858, 1859 and 1860; Great Britain
Colonial Office, pp. 216-245, 314-325.

Heusser, C. J.

- 1956: Post-Glacial Environments in the Canadian Rocky Mountains;
Ecological Monographs, vol. 26, pp. 263-320.

Holland, Stuart S.

- 1964: Landforms of British Columbia, a Physiographic Outline;
British Columbia Department of Mines and Petroleum Resources,
Bull. No. 48, 138 pp.

Horberg, L.

- 1954: Rocky Mountains and Continental Pleistocene Deposits in the
Waterton Region, Alberta, Canada; Bull. Geol. Soc. Am.,
vol. 65, pp. 1093-1150.

Irish, E. J. W.

1965: Geology of the Rocky Mountain Foothills, Alberta (between latitudes 53° 15' and 54° 15'); Geol. Surv. Canada, Mem. 334, 241 pp.

Jeffrey, W. W., Bayrock, L. A., Lutwick, L. E., and Dormaar, J. F.

1964: Land - Vegetation Typology in the Upper Oldman River Basin, Alberta; Forest Research Branch, Dept. of Forestry, Canada, unpubl. 61 pp.

Kiersch, G. A.

1955: Engineering Geology, Historical Development, Scope, and Utilization; Quarterly of the Colorado School of Mines, vol. 50, no. 3, 122 pp.

Kindle, E. M.

1929: The Geological Story of Jasper National Park, Canada; Dept. of Interior, National Parks of Canada, 48 pp.

Krumbein, W. C.

1941: Measurement and Geological Significance of Shape and Roundness of Sedimentary Particles; J. Sed. Pet., vol. 11, pp. 64-72.

Krumbein, W. C. and Pettijohn, F. J.

1938: Manual of Sedimentary Petrography; Appleton - Century - Crofts, Inc., New York, N.Y., 549 pp.

Lang, A. H.

1947: Brule and Entrance Map-areas, Alberta; Geol. Surv., Canada, Mem. 244, 65 pp.

Lindsay, J. D., Pawluk, S. and Odynsky, W.

1960: Exploratory Soil Survey of Alberta Map Sheets 84-M, 84-N, and 84-D; Research Council of Alberta, Prelim. Soil Survey Rept. 61-1, 43 pp.

Lindsay, J. D., Wynnyk, A., and Odynsky, W.

1963: Exploratory Soil Survey of Alberta Map Sheets 83-L, 83-K, 83-F and 83-J; Research Council of Alberta, Prelim., Soil Survey Rept. 64-2, 53 pp.

Mathews, W. H.

- 1963: Quarternary Stratigraphy and Geomorphology of the Fort St. John Area, Northeastern British Columbia; Dept. Mines and Pet. Res., Victoria, B.C., 22 pp.

MacGregor, James G.

- 1962: Pack Saddles to Tete Jaune Cache; McClelland and Stewart Limited, 256 pp.

McEvoy, James

- 1900: Report on the Geology and Natural Resources of the Country Traversed by the Yellowhead Pass Route from Edmonton to Tete Jaune Cache, Comprising Portions of Alberta and British Columbia Geol. Surv. Canada, Ann. Rept. for 1898, vol. II, pt. D, 44 pp. 1901, published as a separate bound volume in 1900.

Mc Crossan, R. G. and Glaister, R. P., editors

- 1964: Geological History of Western Canada; R. G. Mc Crossan and R. P. Glaister, Calgary, Alberta; Alberta Society of Petroleum Geologists, 232 pp.

Means, R. E. and Parcher, J. V.

- 1963: Physical Properties of Soils; Charles E. Merrill Books, Inc., Columbus, Ohio, 464 pp.

Moss, E. H.

- 1955: The Vegetation of Alberta; The Botanical Review, vol. 21, no. 9, pp. 493-567.

Mountjoy, E. W.

- 1958: Jasper Area, Alberta; A Source of the Foothills Erratics Train; J. Alberta, Soc. Pet. Geol. vol. 6, no. 9, pp. 218-226.
- 1960: Miette, Alberta; Geol. Surv., Canada, Map 40-1959.
- 1961: Rocky Mountain Front Ranges along the Athabasca Valley, Jasper National Park, Alberta; Edmonton Geol. Soc., 3rd Ann. Field Trip, pp. 14-42.
- 1962: Mount Robson (Southeast) Map-area, Rocky Mountains of Alberta and British Columbia; Geol. Surv. Canada, Paper 61-31, 114 pp.
- 1964: Rocky Mountain Front Ranges between Rocky River and Medicine Lake, Jasper National Park, Alberta; Edmon. Geol. Soc., Guide Book, 6th Ann. Field Trip, pp. 1-13.

National Soil Survey Committee of Canada

- 1963: Proceedings of the 5th National Meeting of the National Soil Survey Committee of Canada; 92 pp.

Price, R. A.

- 1967: Operation Bow-Athabasca, Alberta and British Columbia in Report of Activities, Part A: May to October 1966, Geol. Surv. Canada, Paper 67-1, Part A, pp. 106-112.

Price, R. A. and Mountjoy, E. W.

- 1966: Operation Bow-Athabasca and British Columbia; in Report of Activities, May to October, 1965, Geol. Surv. Can., Paper 66-1, pp. 116-121.

Richmond, G. M.

- 1965: Glaciation of the Rocky Mountains; In Quarternary of the United States, Wright, H. E., Jr., and Frey, D. (editors), pp. 217-230; Princeton Univ. Press.

Roed, M. A.

- 1965: Bedrock and Surficial Deposits, Cache Percotte Creek Area, Hinton, Alberta, unpubl., Research Council of Alberta, 7 pp.

Roed, M. A., Mountjoy, E. W. and Rutter, N. W.

- 1967: The Athabasca Valley Erratics Train; Canadian J. Earth Sc., Vol. 4, pp. 625-632.

Rubin, Meyer, Likins, Robert, C. and Berry, E. G.

- 1963: On the Validity of Radiocarbon Dates from Snail Shells; J. Geol., vol. 71, pp. 84-89.

Russell, L. S.

- 1965: The Continental Tertiary of Western Canada; Vertebrate Paleontology in Alberta, University of Alberta, Edmonton, pp. 41-52.

Rutherford, R. L.

- 1925: Geology of the Foothills Belt between McLeod and Athabasca Rivers, Alberta; Scientific and Industrial Research Council, Report No. 11, 82 pp.
- 1926: Geology of the Area between Athabasca and Embarras Rivers, Alberta; Scientific and Industrial Research Council, Report No. 15, 29 pp.

Rutherford, R. L.

- 1928: Geology of the Area between North Saskatchewan and McLeod Rivers, Alberta; Research Council of Alberta, Rept. 19, 37 pp.

Rutter, N. W.

- 1965: Surficial Geology of the Banff Area, Alberta; Univ. Alberta, Dept. of Geology, Ph.D. thesis, 105 pp.
- 1966: Glacial History of the Bow River Valley, Banff, Alberta; The Canadian Alpine Journal, Vol. 49, pp. 157-172.

St. Onge, D. A.

- 1967a: Surficial Geology, Iosegun Lake (East Half); Geol. Surv. Canada, Map. 15 - 1966.
- 1967b: Quaternary Geology and Geomorphology, Whitecourt (83-J) Map-area; Geol. Surv. Canada, Paper 67-1, Part A, pp. 115-117.
- 1968: Quaternary Geology and Geomorphology, Whitecourt (83-J) Map-area, Alberta; Geol. Surv. Canada, Paper 68-1, Part A, pp. 186-189.

Schultz, J. R. and Cleaves, A. B.

- 1955: Geology in Engineering; New York, John Wiley and Sons, Inc., 592 pp.

Simons, D. B. and Richardson, E. V.

- 1961: Forms of Bed Roughness in Alluvial Channels; Amer. Soc. Civil Eng. Proc., 87, No. HY #3, Paper 2816.

Stalker, A. MacS.

- 1956: The Erratics Train, Foothills of Alberta, Geol. Surv. Canada, Bull. 37, 19 pp.
- 1963: Quaternary Stratigraphy in Southern Alberta; Geol. Surv. Canada, Paper 62-34, 52 pp.

Stene, L. P.

- 1966: Pleistocene Valley Train Terraces Along the Athabasca River in the Hinton Area, Alberta; Univ. Alberta, Dept. of Geography, M.Sc. thesis, unpubl., 58 pp.

Taylor, R. S.

- 1958: Some Pleistocene Lakes of Northern Alberta and Adjacent Areas; Edmonton Geol. Soc. Quart., vol. 2, No. 4, 8 pp.

Tharin, James C.

- 1960: Glacial Geology of the Calgary Area; Univ. Illinois, Ph.D thesis, University microfilms, Pub. No. 61 - 209, Ann Arbor, pp. 16-18.

Travis, Russell B.

- 1955: Classification of Rocks; Quarterly of the Colorado School of Mines, vol. 50, No. 1, 98 pp.

Wagner, W. P.

- 1966: Correlation of Rocky Mountain and Laurentide Glacial Chronologies in Southwestern Alberta, Canada; Unpublished, Ph.D. thesis, University of Michigan, 141 pp.

Williams, G. D. and Bayrock, L. A.

- 1966: Surficial Geology between Edmonton and Cadomin near Highways 16 and 47 (Appendix: Road Log of Highways 16 and 47 between Edmonton and Cadomin); Edmonton Geological Society, 8th Annual Field Trip, Guidebook pp. 105 - 134.

APPENDIX A

LABORATORY INVESTIGATIONS

Introduction

The techniques, numerical data, and principal results of the various investigations on till and gravel are summarized in the following pages.

Grain Size Analysis

Method of Investigation

Till samples were gently broken up with a wooden rolling pin and then sieved through a 10 mesh screen (2 mm. size). The material coarser than this size was discarded. A 50 gram sample was employed in the hydrometer method of grain size analysis for the fraction of till finer than 2 mm. (Bouyoucos, 1951). The carbonates were not removed prior to the analysis.

Results

Most of the tills in the area fall within the loam, clay loam, or clay categories. As shown in the texture triangle of Figure 13 (values from which the texture triangle was constructed are given in Table 10), the results show that Continental and Cordilleran tills are somewhat similar in grain size, but the Cordilleran till is generally coarser grained. Cumulative curves showing the range in grain size for each till map unit are given in Figure 20.

TABLE 10 Grain size distribution of till samples for the size fraction finer than 2.00 mm.

NAME OF TILL	SAMPLE NUMBER	PERCENTAGE		
		SAND	SILT	CLAY
Drystone Creek	36-4	30	38	32
	39	42	31	27
Obed	67	42	31	27
	179	30	41	29
	188-17	25	45	30
	188-18	45	27	28
	197	40	32	28
Marlboro	146	42	35	23
	187	40	43	17
	188-4	66	19	15
	198	39	20	41
	221	25	44	31
	271-1	40	30	30
	272	50	34	16
Raven Creek	210	26	37	36
	229	44	28	28
	241	39	34	27
	270-1	48	22	30
Mixed	223	34	26	40
Mayberne	215	29	40	31
	216	45	23	32
	249	33	52	15
	268	10	59	31
Edson	192	26	27	47
	214	49	31	20
	265-3	27	29	44
	277-2	43	31	26
	278-1	27	32	41
	278-3	31	30	39
Marsh Creek	271-3	40	30	30

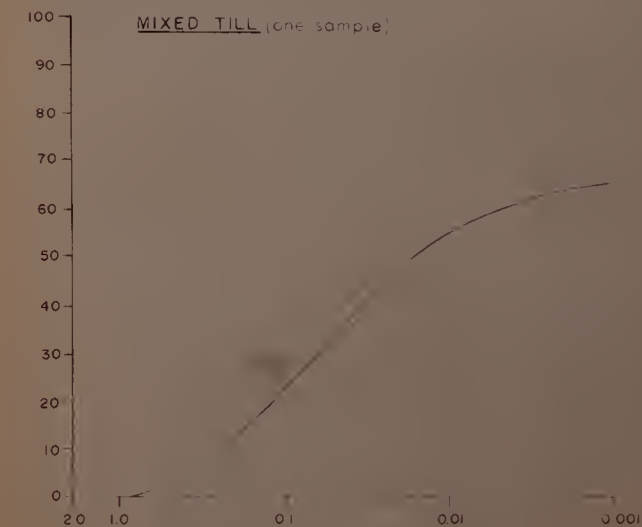
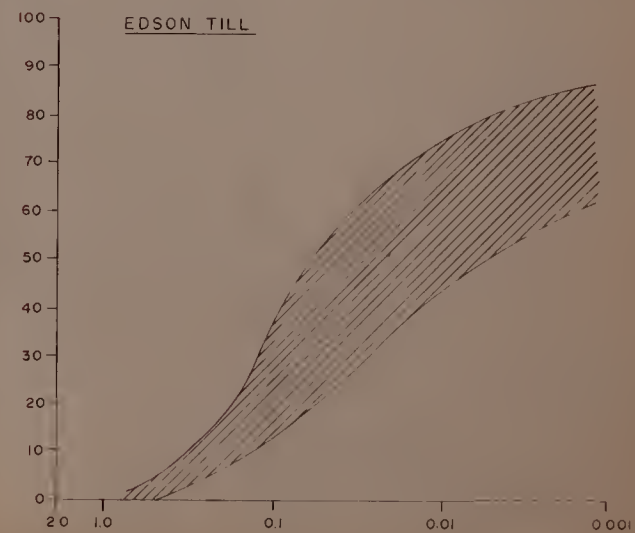
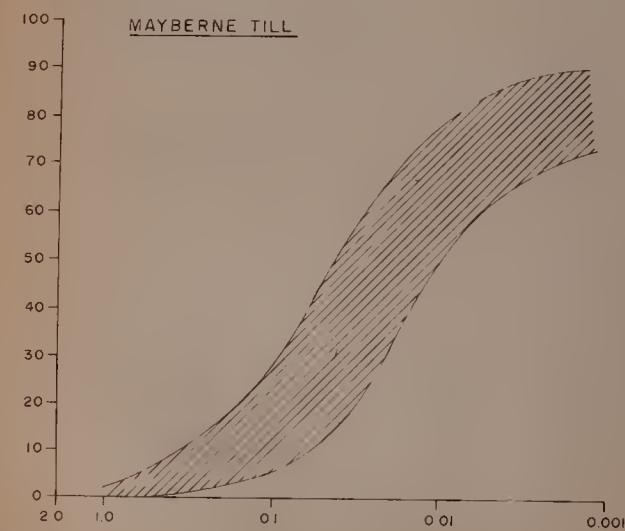
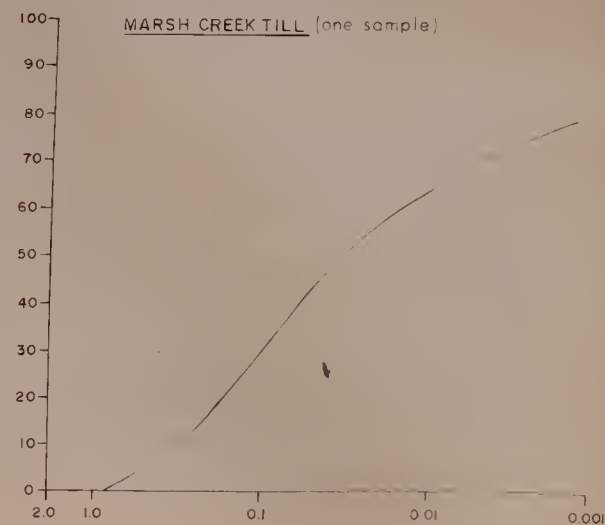
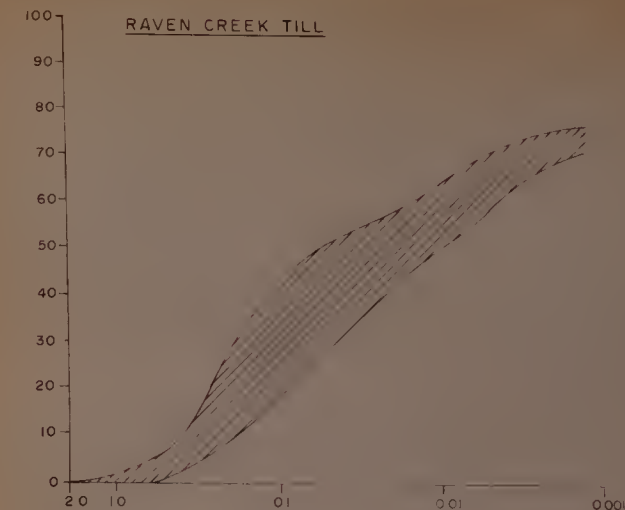
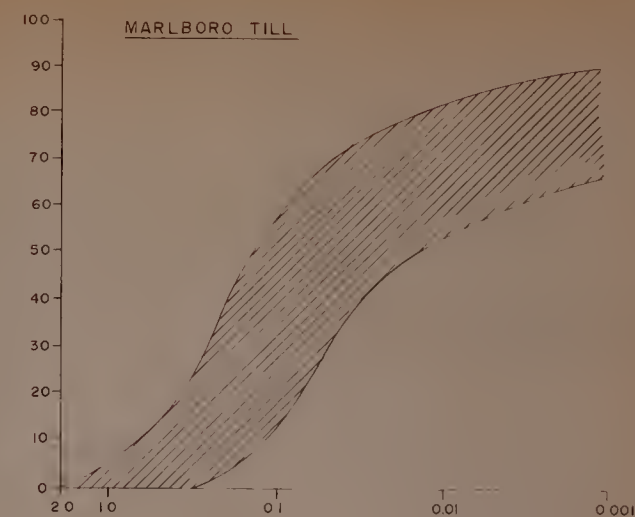
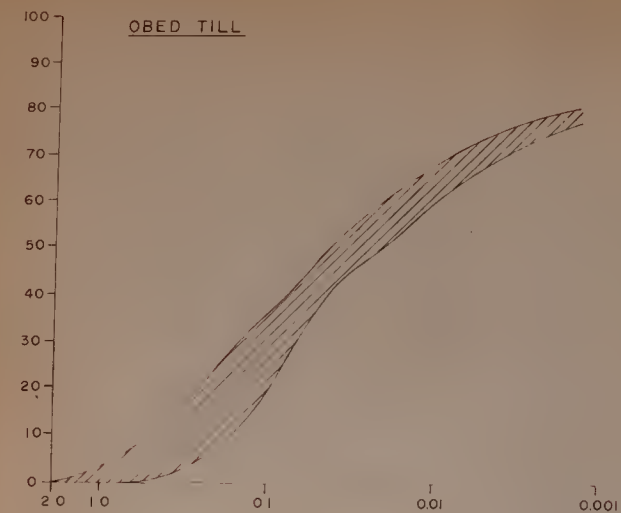
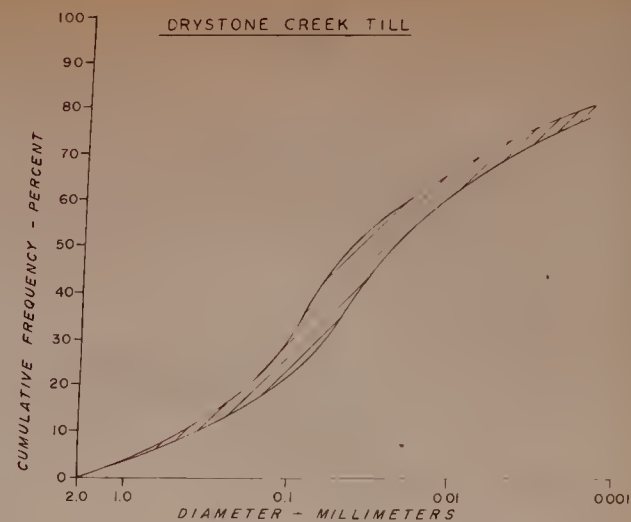


FIGURE 20 - RANGE IN GRAIN SIZE OF TILL SAMPLES IN EDSON - HINTON AREA

Roundness

Method of Investigation

The roundness of every pebble in each sample was determined by using Krumbein's (1941) chart for visual roundness. The pebbles investigated range between 6 and 64 mm. in diameter.

Results

1. The average roundness for each principal lithologic type in the various tills is given in Table 7. The overall average roundness of all pebbles is 0.5.

2. Metaquartzite is the only ubiquitous lithologic type of pebble in the several tills. There is no discrepancy in the roundness of these pebbles within the tills however, a comparison of the roundness in till and the roundness in an undisturbed gravel deposit (an outcrop of Tableland gravel of metaquartzite lithology and believed to be of Tertiary age on a high level terrace at Locality No. 266) reveals a roundness difference for metaquartzite pebbles. Figure 17 is such a comparison and indicates a major difference in roundness. The Tertiary gravel has a concentration around a value of 0.9 and the tills have a concentration at values of 0.5 to 0.8. An examination of these pebbles suggests that the difference lies in an abundance of broken pebbles in the till and a lack of broken pebbles in the original gravel. It may be possible, therefore, to distinguish till from gravel by roundness investigation at localities where there is difficulty in identifying these two sometimes similar deposits.

3. Roundness of limestone pebbles is different in Cordilleran tills of local origin and tills of distant origin. Figure 18 compares the roundness of limestone pebbles in the

AVERAGE ROUNDNESS OF PEBBLES IN TILLS

TABLE 7

(The number of pebbles is given in Table 3)

NAME of TILL		British Columbia schist	Shield granite, diorite	Shield gneiss	Quartz sandstone	Feldspathic, arkosic sandstone	Metaquartzites	Limestone	Dolomite	Mudstone, shale, argillite	Siltstone, dolomitic sandstone	Lithic sandstone, chert conglomerate	Coal, chert, quartz
Cordilleran Source	Drystone Creek	.7					.7	.4	.4		.4	.4	
	Obed	.5			.5	.5	.6	.5	.6	.5	.5	.5	.4
	Marlboro and Raven Creek	.2	.3	.5	.5	.5	.5	.6	.6	.5	.5	.6	.5
Canadian Shield Source	Edson, Mayberne, and Marsh Creek		.5	.5	.5	.5	.7	.6	.5	.4	.5	.5	.5

Drystone Creek till (Drystone Creek, Locality Nos. 35 and 39) to limestone pebbles in the Obed till (see Table 5 for localities). Although the modal class of roundness is about 0.5 in both tills, the following differences are present: (a) The Drystone Creek till has a lack of rounded pebbles (0.6, 0.7) and no well rounded types (0.8, 0.9). (b) The Obed till is deficient in angular pebbles (0.1 to 0.4) and has an abundance of well rounded pebbles (0.6 to 0.9).

The difference in roundness is attributed to the distance of transport of the respective tills, the limestone pebbles in the Obed till being driven from a greater distance than those in the Drystone Creek till (Figure 2). An equally acceptable explanation is that the Obed till contains pebbles that were previously rounded by fluvial erosion in the major stream valleys.

Pebble Counts

Method of Investigation

One hundred pebbles were randomly collected from selected localities. The pebbles vary greatly between 4 and 64 mm. This sampling technique has been used successfully by Rutter (1965, p. 37). The rocks were grouped by major lithologies which correspond generally to a certain geological age and to general source areas. Percentage error was not calculated, but curves for estimation of probable error which can be used are given by Krumbein and Pettijohn (1938, figure 245, p. 472).

Results

Table 5 shows the results of the pebble counts in detail, whereas Table II and Figure 12 are summaries of this table and illustrate the major pebble lithologies of the various tills important for field identification.

The Cordilleran tills contain limestone, feldspathic orthoquartzite, quartzose

TABLE 5

Pebble count results of till and gravel samples

(in percentage, 100 pebbles used in each sample).

General Source and Age	Canadian Shield Precambrian	Cordilleran Precambrian	Cordilleran Lower Cambrian to Precambrian	Mainly Cordilleran Paleozoic	Mainly Cordilleran Triassic-Jurassic	Mainly Plains Cretaceous Tertiary	Other					
DEPOSIT (NAME OF TILL OR GRAVEL)	Crystalline granite, diorite, etc.	High grade metamorphic rocks	British Columbia schist (foliose, garnet, biotite schists)	Metagranites	Orthoquartzite	Feldspathic and arkosic orthoquartzite	Limestone	Dolomite	Mudstone, shale and argillite	Siltstone and dolomitic sandstone	Lithic sandstone and chert conglomerate	Chert, chert, quartz
36-4 Drystone Creek Till	-	-	-	4	-	2	74	6	-	10	4	-
39	-	-	1	2	-	-	80	8	-	5	4	-
67	-	-	-	14	4	13	40	12	-	12	2	3
179	-	-	-	10	16	5	36	9	4	6	13	1
188-17	-	-	-	14	16	4	28	6	3	14	11	4
188-18	-	-	-	19	13	4	33	12	3	10	4	2
197	-	-	5	23	13	10	17	4	5	13	11	2
200-2	-	-	-	27	4	1	30	13	2	13	7	3
239-2	-	-	-	13	16	7	26	13	4	5	16	-
146	-	-	2	18	7	13	7	-	6	4	34	11
180	-	-	-	41	13	8	14	7	1	7	7	2
187	-	-	-	19	13	11	17	4	7	9	16	4
188-4	-	-	-	29	10	13	23	7	1	8	6	3
198	-	-	-	48	6	13	-	4	2	9	12	6
221	-	-	-	71	4	10	-	-	-	6	3	6
232-5	-	-	-	27	9	10	22	7	1	14	8	2
?	7	-	-	48	5	19	2	2	2	-	7	7
211	-	-	-	24	4	4	40	12	4	6	3	3
229	3	-	-	27	5	7	4	2	10	20	27	5
241	2	-	-	22	3	1	28	18	4	7	11	4
270-1	-	-	-	13	8	4	45	16	3	3	7	1
223	11	11	-	44	8	8	-	2	3	5	3	5
215	-	-	-	86	5	6	-	-	-	-	-	3
216	3	2	-	74	4	8	-	1	-	-	4	4
249	2	-	-	76	9	7	-	-	-	2	-	4
192	6	2	-	39	3	6	4	3	24	2	6	5
214	3	-	-	62	4	7	6	1	6	-	7	4
265-3	8	2	-	42	6	12	3	4	5	-	9	10
277-2	3	-	-	43	4	12	11	3	6	3	6	9
271-3	10	2	-	37	5	4	8	5	12	9	4	3
266	-	-	-	72	18	10	-	-	-	-	-	-
263-3	-	-	-	70	6	14	-	-	-	4	1	5
278-4	-	-	-	39	4	1	22	10	-	9	8	7
271-2	5	-	-	60	6	11	-	-	-	-	11	7

sandstone, orthoquartzite, and metaquartzite (Travis, 1955, p. 21) pebbles derived mainly from the Rocky Mountains and Foothills. In contrast the Continental tills contain some limestone pebbles, some crystalline rocks of Canadian Shield origin and numerous metaquartzites. In the case of the Raven Creek till, pebbles are mainly Cordilleran in origin but a few crystalline pebbles of Canadian Shield source are present. From this and other evidence it has been inferred that the Raven Creek till was deposited by a Cordilleran glacier which advanced over a pre-existing Continental till.

Table 11 - Average Pebble Composition of Cordilleran and Continental Tills

Rock Type	Cordilleran Till (Average Percentage) (21 Samples)	Continental Till (Mixed Till Excluded) (8 Samples)
Crystalline granite diorite, etc.	0.6	3
High grade metamorphic	0	0.9
B. C. schist and gneiss	0.4	0
Metaquartzite	27	57
Orthoquartzite	0.5	8
Feldspathic and arkosic ortho- quartzite	0.8	8
Limestone	27	8
Dolomite	8	2
Mudstone, shale, argillite	3	7
Siltstone, dolomitic sandstone	9	2
Lithic sandstone, chert conglomerate	10	4.5
Coal, chert, quartz	3	4

In the Cordilleran tills the limestone percentage decreases with increasing age as is illustrated by the descending sequence of Drystone Creek, Obed, and Marlboro tills. The over-all range of pebble composition is also significant in that the Drystone Creek till contains mainly local bedrock material, the Obed till a wide variety of erratics but always with a high limestone percentage, and the Marlboro till a wide variation in pebble composition in which limestone may be rare or absent. These variations are due mainly to the material underlying the glacier and to the source of ice. For instance, the Obed till was deposited by a valley glacier which may have eroded outwash confined to the major valleys of the mountains; also, it was probably derived mainly from the Front Ranges of the Mountains which are dominantly limestone and orthoquartzite. The Marlboro till on the other hand was deposited by a much larger glacier of piedmont dimension which overrode a wide variety of material. The greatest range in pebble lithology would therefore be expected in the Marlboro till and this is the case. In the area of the Pembina River, the Raven Creek till, a lithofacies of the Marlboro till, is rich in limestone; this is understandable since the till was probably eroding extensive limestone-bearing outwash deposits from the Front Ranges of the Rocky Mountains to the west. This is supported by the high percentage of limestone in the gravel beneath the till at locality No. 210.

Metaquartzite pebbles are the dominant constituent of the Pleistocene-Tertiary gravels and were probably present over the entire area at one time or another. Their ubiquity in till is therefore to be expected. In some places, for instance the Mayberne Tableland, the metaquartzites are so numerous in the till that a separate map unit, the Mayberne till, has been established. This in turn is explained in that Mayberne Tableland is underlain by the Tableland gravel which contains a large

percentage of metaquartzites (Table 5, Locality No. 266).

Pebbles derived from west of the Continental Divide are not prominent in the pebble counts, but these erratics, which include a variety of low to medium grade metamorphic rocks (Table 1, Figure 5, Plate I) have received special study (Roed, et. al., 1967). They comprise the Athabasca Valley Erratics Train and are associated with both the Obed and Marlboro tills. This erratics train is discussed in more detail in Appendix B.

Heavy Mineral Analysis

Method of Investigation

Heavy minerals were separated by means of tetrabromoform (2.890 s.g.), by standard procedures, from the size fraction finer than 2.0 mm. and coarser than 0.74 mm. of selected till and gravel samples. Carbonates and iron oxides were removed beforehand with concentrated HCl. The heavy mineral grains finer than .177 mm. (80 mesh) were mounted on glass slides using (Aroclor ($n = 1.66$ to 1.67)). An average of about one hundred non-opaque grains, but ranging from fifty-seven to one hundred seventy-nine, were identified and counted on each slide. Unidentified minerals, which never exceeded two or three per cent, were excluded from the results. The total number of opaque grains was counted for each slide but these grains were not identified. Percentage error was not calculated, but curves for estimation of probable error which can be used are given by Krumbein and Pettijohn (1938, figure 245, p. 472).

Results

Table 4 shows the percentage of each variety of heavy mineral counted and Table 12 shows the average heavy mineral composition of Cordilleran and

Percentage of non-opoque heavy minerals from till and gravel samples

(0.74 mm. to .177 mm. size range)

Name of till* or Gravel	Sample Number	Zircon I rounded crystal	Zircon II aggregate	Zircon III crystal or fragment	Zircon IV hyaline	Garnet I crystal	Garnet II fragment	Tourmaline I brown	Tourmaline II green	Tourmaline III blue	Chloritoid	Chlorite	Epidote	Collophane	Hornblende	Pyroxene	Hypersthene	Sphene	Clinozoisite + Zoisite	Staurolite	Rutile + Brucite	Andalusite	Allonite	Kyanite	Total number of non-opoques	
Drystone Creek	36-4 67	4 7	5 5	2 4	5 7	- 3	10 7	2 7	5 2	- -	60 34	2 2	2 7	2 -	- -	- 1	- -	- -	- 1	2 5	- 3	2 -	- 7	- 1	- -	57 53 103 112
Cbed	179 188-17 188-18 197 200-2 239-2	1 3 6 12 5 4	10 6 6 8 10 8	11 6 4 13 13 12	tr 10 6 4 4 6	7 6 3 tr 4 7	26 19 11 9 9 23	4 6 2 3 7 2	- - 2 tr -	- - tr -	13 23 32 32 12 16	2 3 5 8 7 2	8 8 11 9 9 12	2 8 3 11 5 7	2 -	tr -	tr -	3 2 tr tr 1 -	tr 2 tr 8 1 -	1 2 2 4 3 -	1 2 tr -	- tr -	- tr -	169 190 124 124 155 144 115 121 99 175 179 171		
Morilboro	146 180 187 189-4 221 239-5 271-1 272	2 3 2 3 tr 8 2 10	13 13 24 10 8 17 9 6	11 20 15 17 13 16 17 13	3 3 2 4 3 3 4 3	3 2 2 2 4 4 tr	2 30 28 39 25 11 31 30	5 9 3 2 tr 3 4	- - 2 tr tr 2 2	- - - tr tr 2 3	25 12 13 19 27 10 12	7 2 tr 3 5 7 4 2	9 9 tr 10 3 5 9 5 7	6 tr -	tr -	tr -	- -	3 2 2 tr 4 tr	tr 2 2 -	2 tr 3 3 2 1 2	2 tr -	- tr -	- -	126 107 110 88 114 63 120 85 110 104 90 75 112 119 124 154		
oven Creek	210 229 241 270-1	10 3 3 5	9 14 13 10	9 12 15 13	1 - tr 3	3 7 tr 3	32 25 2 35	3 4 2 2	1 - - -	- - - -	6 5 tr 8	8 2 tr 3	10 15 12 17	3 - tr -	- 3 -	1 -	- -	5 - tr 3	- tr 3 2	- tr 4 3	- tr 1	- tr -	- -	- -	105 60 110 80 120 101 108 77	
Mixed	223	2	10	13	-	3	29	4	tr	-	4	-	2	-	9	tr	6	4	tr	5	2	-	-	2	120 85	
Moybeme	215 216 249 268	8 8 10 5	10 8 17 7	17 12 17 25	2 2 tr 3	4 3 tr tr	10 38 11 13	tr 4 2 2	- 4 2 -	- - - -	2 2 6 24	2 tr 8 -	5 4 8 66	- - 12 -	21 6 -	3 -	- -	5 -	2 4 2 tr	2 3 2 5	2 3 3 -	tr -	- -	- -	2 120 240 112 90 113 113 110 80	
	214 265-3 271-3 278-1 278-3	3 7 4 3 5	13 6 7 12 13	19 21 13 15 10	- - tr 2 1	3 4 4 4 7	29 29 34 24 26	4 1 2 2 1	- 1 tr 2	- - tr 2	- - tr 2	3 4 4 4 2	tr 1 7 -	4 7 3 10 9	- - 16 13 12	9 3 5 tr 2	2 3 2 2 2	2 2 tr 2	3 - - 2	3 4 tr 5	2 - tr 1	- -	- -	119 90 135 90 113 13 116 111 107 14		
Marsh Creek	277-2	5	10	7	3	3	43	3	4	-	11	2	2	-	6	2	1	2	-	2	2	-	-	2	104 70	
*Tobleland Gravel	266	5	tr	8	2	-	5	5	tr	-	8	2	2	-	-	8	2	5	2	23	9	-	-	-	13	126 80
Lowland Gravel	263-3	14	14	13	1	30	1	-	2	-	3	1	9	-	3	-	-	2	2	5	-	-	-	-	-	109 110
Buried Valley Gravel	278-4	3	9	9	3	4	53	11	1	-	2	-	5	-	-	-	-	3	-	4	4	-	-	-	-	102
Marsh Creek Outwash	271-2	5	4	4	1	-	38	4	3	-	1	1	1	-	23	4	4	1	-	-	1	-	2	1	101	

* The last four samples are from four different gravel deposits.

Continental tills.

Heavy Minerals in Till: Two assemblages of heavy minerals are present in the till samples, one of which corresponds to Continental tills and the other to Cordilleran tills. The relative abundance of the main heavy minerals of the two kinds of till can be compared in Table 12 and Figure 12.

The main differences are: (1) Continental tills contain hornblende, pyroxene, kyanite, and hypersthene whereas Cordilleran tills do not; (2) Chloritoid, chlorite, and epidote are more common in Cordilleran tills than in Continental tills.

The main conclusion is that heavy minerals in the tills are diagnostic of source area and support the differentiation of respective map units.

Heavy Minerals in Gravel: The heavy minerals of four different gravel samples were also studied with equally interesting results. However, due to the low number of samples collected, only very general comments are possible. The heavy minerals of the four different gravel units are given at the end of Table 4. These samples were not treated with HCl. The conclusions are:

1. Lowland and Buried Valley gravel units carry a typical Cordilleran assemblage of heavy minerals similar to the Cordilleran tills of the area. This suggests that these gravels may have been deposited by glacial meltwater or streams derived from the Rocky Mountains before advance of the earliest Continental glacier.

2. The heavy mineral suite of the Tableland gravel is so different from either the Lowland or Buried Valley gravel that a different source must be inferred. The striking differences are that the Tableland gravel contains much more staurolite,

rutile and kyanite than the other two units. These minerals are characteristic of medium grade metamorphic rocks. The source of this gravel therefore, is to the west of the Rocky Mountain Trench since there are no such rock types in the Rocky Mountains (Roed et al., 1967). The absence of crystalline rocks of the Canadian Shield in the gravel precludes a source from the Canadian Shield.

3. Heavy minerals from the glacial outwash gravel of the Oldman Creek Section (No. 271, Appendix C) are typical of a Continental source. This agrees with the field evidence since the gravel unit overlies Continental till (Marsh Creek till) and underlies Cordilleran till (Marlboro till), and contains numerous pebbles of crystalline rocks derived from the Canadian Shield (Section No. 271, Unit 2).

Discussion: The heavy mineral assemblage of Cordilleran tills found in the area agrees well with that found by Rutter in the Banff area (1965, p. 41 and 42) with two important exceptions: (1) Tills in the Banff area contain appreciable hypersthene and those in the Edson-Hinton area rarely contain hypersthene. Rutter (1965, p. 42) suggests that the hypersthene indicates the presence of unreported volcanic ash. The paucity of hypersthene in Cordilleran tills of the Edson-Hinton area, in relation to Rutter's work, indicates that the unreported volcanic ash cannot be detected in this area. (2) Tills of the Edson-Hinton area are rich in garnet whereas tills in the Banff area contain a relatively small amount of garnet in most samples. This may be due to the different rock types over which the glaciers flowed.

The most important heavy mineral indicator of Continental tills is hornblende. However, in comparison with the percentage of hornblende found in

TABLE 12 - Average Heavy Mineral Composition of Cordilleran and Continental Tills

	Average Percentage (Mixed Till and Marsh Creek Till excluded)	
Types of Heavy Mineral	Cordilleran Till (19 samples)	Continental Till (9 samples)
Zircon	29	33
Garnet	26	30
Tourmalene	4	3
Chloritoid	20	6
Chlorite	4	tr
Epidote	9	tr
Collophane	1	-
Hornblende	-	11
Pyroxene	tr	2
Hypersthene	-	1
Sphene	2	3
Clinozoisite-Zoisite	2	2
Staurolite	2	3
Rutile-Brucite	1	1
Andalusite	tr	-
Allanite	tr	-
Kyanite	-	2

tr = trace (1%)

Continental tills of east-central Alberta (Bayrock, 1962) and the amount in Continental tills of the Edson-Hinton Area (this study), it is obvious that hornblende is deficient in the present area. The only explanation offered here for this discrepancy is that the Continental ice in the Edson-Hinton area was "diluted" with respect to heavy mineral concentration of hornblende because the ice in this area was at its maximum extent of expansion.

A general similarity exists between heavy minerals present in the Low-land gravel unit and those described in the Saskatchewan Sands and Gravels by Antoniuk (1954). The Tableland gravel suite of heavy minerals, however, is quite different from any unit Antoniuk described.

Carbonate Content in Matrix of Till Samples

Method of Investigation

Quantitative gasometric determination of the calcite and dolomite content of the till sample fraction finer than .074mm. was determined by use of the Chittick apparatus. The procedure followed is outlined by Dreimanis (1962), and duplicate runs were made for each sample.

Results

Table 13 gives the determination of the carbonate analysis of the various tills in the area. The carbonate content is distinct for all major till units but may vary locally. The variation within each map unit cannot be evaluated because of the lack of access needed to obtain representative samples.

TABLE 13. Percentage of Carbonate in less than .074 mm. size fraction of till.

Name of Till	Sample Number	% Carbonates	Calcite-Dolomite Ratio	Average % Carbonate
Drystone Creek	36-4	40.3	1.8	45.2
	39	50.0	1.6	
Obed	67	30.0	1.5	19.8
	179	13.7	1.7	
	188-17	19.4	1.2	
	188-18	20.7	0.8	
	197	9.1	1.0	
	200-2	27.1	3.2	
	239-2	18.2	1.7	
Marlboro	*146	1.7	0.4	13.5
	180	14.8	3.4	
	187	14.6	1.1	
	188-4	15.6	1.5	
	*198	2.0	1.2	
	221	1.7	0.8	
	239-5	22.6	2.1	
	271-1	12.1	1.9	
	*272	0.9	0.3	
Raven Creek	210	11.4	0.6	11.0
	229	5.5	5.1	
	241	10.6	0.5	
	270-1	16.5	1.0	
Mixed	223	0.7	*0.16	0.7
Mayberne	215	1.3	*0.4	1.8
	216	3.1	*0.2	
	249	0.9	*0.03	
Edson	192	5.6	1.0	5.1
	214	5.6	1.1	
	265-3	4.2	*0.5	
Marsh Creek	271-3	5.3	*0.9	5.3

* Leached sample, not included in calculation of average value; other samples are taken from below a depth of five feet.

The main findings are that the Continental tills (Edson, Mayberne and Marsh Creek tills) have an average carbonate content of 4 per cent as opposed to the following values for Cordilleran tills: Marlboro till, 14 per cent; Raven Creek till, 11 per cent, Obed till, 20 per cent, and Drystone Creek till, 45 per cent. On the basis of the carbonate content therefore, a till of Continental origin differs markedly from one of Cordilleran origin in that Continental tills have a very low carbonate content. Also, the Drystone Creek till, believed to be of local derivation, has a very high carbonate content as opposed to that of the Obed till which has a more distant source. L. A. Bayrock concluded that the same distinction was valid for the headwaters area of the Oldman River (Jeffrey, et al., 1964, p. 14). Carbonate content is therefore a useful distinguishing characteristic.

Stoniness

Definition

It was obvious in the field that some tills contained many more stones (or erratics) than other tills. Furthermore, the relative abundance or scarcity of stones, referred to as stoniness, was found by empirical methods in the field to be generally uniform for a certain till.

Method of Investigation

The various tills were empirically described as moderately stony, very stony, etc., but in order to place some values on these descriptive terms the following procedure was employed.

1. All erratics or stones greater than one-quarter inch diameter were counted in an area of 16 square feet over a till outcrop. The outcrop in most localities was a ditch cut which exposed at least five feet of till.
2. A total of four counts was made at each locality; two of the counts were made by one person and two made by another person (comparison of the different totals was generally good but varied in counts over four hundred).
3. An average of the four counts was taken and this number was used as a measure of the relative stoniness in the following scale:

0 to 100 - stone poor

100 to 250 - moderately stony

250 to 600 - very stony

Results

Table 14 gives stoniness values of some tills in the area. No attempt was made to statistically measure variation in stoniness.

TABLE 14 Quantitative Stoniness Measurements

<u>Locality</u>	<u>Name of Till</u>	<u>Average No. of Pebbles in 16 sq. ft.</u>	<u>Relative Stoniness</u>
214	Edson	44	stone poor
218	Edson	57	stone poor
265	Edson	70	stone poor
285	Edson	201	moderately stony

249	Mayberne	155	moderately stony
286	Marlboro	164	moderately stony
287	Marlboro	163	moderately stony
288	Obed	555	very stony
289	Obed	470	very stony

Conclusions

The relative stoniness is useful in determining whether a till is of Cordilleran or Continental origin at many localities, but considerable overlap of the respective values occurs in some areas depending on the underlying material. Therefore, stoniness cannot be confidently used to determine the origin of a till since the stoniness probably depends on the composition of the underlying material and the ease of incorporation of this material into the ice. Stoniness, however, is of value as a descriptive term.

APPENDIX B

RELATIONS OF THE ATHABASCA VALLEY ERRATICS TRAIN AND
THE ERRATICS TRAIN, FOOTHILLS OF ALBERTA

Introduction

The following is an account of some relationships between the Athabasca Valley Erratics Train (Roed et al., 1967) and the erratics train of Stalker (1956).

Erratics Train, Foothills of Alberta

Summary

Large, angular erratics of light gray to light purple, massive to bedded orthoquartzite, quartzitic sandstone, and feldspathic orthoquartzite and sandstone (Travis, 1955, p. 21), with some pebbly varieties, occur in the Marlboro till (some of the more unusual localities are given in Figure 5). These rocks are judged to be similar to the erratics of the erratics train described by Stalker (1956, p. 10) as "fine pebble conglomerate and coarse, massive to bedded quartzite, cross bedding being commonly displayed." Mountjoy (1958, p. 224) suggested on the evidence of regional mapping that these erratics were derived from the Cavell Formation (Gog Group) in the Jasper area by a glacier flowing out of the Athabasca valley. Further, Roed et al., (1967) have suggested that ice moving out of any of the valleys of the Smoky River drainage system, north of the Athabasca River, could have incorporated the same kind of erratics. Firstly, regarding the identification of the source of the

erratics, there has been no mineralogic comparison detailed enough to positively establish the source area. Secondly, not enough is known about the frequency of Cordilleran glacial advances at present to be sure which glacier carried erratics of the erratics train. The possibility of Cordilleran ice bearing with it erratics of the erratics train moving southeasterly from the Smoky River drainage system at some time during the Pleistocene has not been ruled out by the present study. However, the glacier which deposited the Marlboro till certainly carried these erratics, but so did the glacier which deposited the inferred "Early" Cordilleran till of this study (Figure 5). The problem therefore awaits resolution by further mapping and detailed lithologic and stratigraphic studies.

Relationship

The relationship of the Athabasca Valley Erratics Train and the erratics train of Stalker is extremely interesting since it involves a major glacial event in the area. This event is the latest known deflection of Cordilleran ice by Continental ice. The Athabasca Valley Erratics Train in the Marlboro till is confined mainly to the northern part of the Athabasca Tableland. Lobate end moraines in that area (Figure 2, Plate 16) strongly suggest that part of a large piedmont glacier advanced to the north over the Athabasca Tableland, came in contact with Continental ice around Tp. 56 to 57 and remained in that position. At the same time ice must have been flowing to the southeast out of the Athabasca valley, the same ice which must have carried erratics similar to the Erratics Train, Foothills of Alberta. The question is - was the southeasterly moving ice part of the ice stream which deposited the erratics train in a linear belt 350 miles south to the International Boundary active while the lobe containing the Athabasca Valley Erratics Train remained more or less inactive;

or was this ice carrying the Athabasca Valley Erratics Train and associated southeasterly moving ice a later glacial advance? The latter suggestion is entirely possible in which case a terminal moraine for the southeast moving portion of this later glacial advance should be present southeast of the Edson-Hinton area. There is no evidence for such a terminal moraine in the area.

Conclusion

In conclusion, the relationships between the Athabasca Valley Erratics Train, Foothills of Alberta, are not clear, but it is obvious that they are related and are of extreme importance in deciphering the glacial history of this part of Alberta.

APPENDIX C

STRATIGRAPHIC SECTIONS

The following descriptions of measured stratigraphic sections are described starting with the youngest and ending with the oldest sediments. See Figure 11 for location and localities.

Section Name: Drystone Creek
Section No. 39

Surface Form: Ground Moraine
Location: NE 1/4 Sec. 18, Tp. 49, R. 26 W5

Unit No.	Lithology Description	Thickness (Feet)
----------	-----------------------	------------------

Drystone Creek Till (type section)

- | | | |
|---|---|----|
| 1 | <p>Till, brownish grey to medium grey, very stony, mode 1" diameter, up to 4', sub-angular, some subrounded, mainly limestone, some quartzite, sandstone and siltstone; calcareous silty clay matrix; uniform throughout except for 1' sand 4' below top of cut bank.</p> <p>Contact with underlying gravel (units 2 & 3) sharp and even in all places.</p> | 25 |
|---|---|----|

Outwash

- | | |
|---|--|
| 2 | <p>Sand, well bedded, banded, coarse grained, moderately well sorted, some pebble gravel lenses, not</p> |
|---|--|

continuous, sharp contact with overlying till,
gradational contact with underlying gravel. 5

Outwash

- 3 Gravel, mode 1" diameter up to 4' subangular,
some subrounded, most fragments tabular; mainly
limestone, sandstone, with some light coloured
quartzites, rare chert conglomerate; poor bedding,
indistinct. 40

Fernie Formation (Jurassic)

- 4 Shale -

Total 70

Section Name: Old Railway
Section No. 67

Surface Form: Drumlin
Location: NE 1/4 Sec. 10, Tp. 52, R. 24

Unit No.	Lithology Description	Thickness (Feet)
	Obed Till	
3	Till, light grey brown; very stony, compact; pebble mode 3/4", up to 1' diameter, angular to subrounded; mainly quartz sandstone, orthoquartzite and feldspathic orthoquartzite, limestone, siltstone and local bedrock; matrix sandy clay.	2 - 10
	Pedley Sediments	
2	Gravel, well bedded, lower 3' - pebble gravel, mode 3/4" up to 10", subrounded, mainly quartz sandstones and limestones; matrix 30% medium to coarse gravel; upper 5 1/2' pebble gravel, mode 1" up to 6"; mainly quartz sandstones and limestones; distinctly banded; matrix 30%, very fine to coarse grained. Irregular contact with overlying till, appears erosional	8.5 - 15
1	Talus slope, obscures lower part of section	30 - 40
	Total	10.5 - 25+

Section Name: CNR Bridge
Section No. 125

Surface Form: Lateral Moraine
Location: NW 1/4 Sec. 5, Tp. 51, R. 25 W5

Unit No.	Lithology Description	Thickness (Feet)
1	Soil Profile	1
	Obed Till (oxidized)	
2	Till, sandy, stony, 1/8" to 12" diameter, lenses of calcareous silt; light greyish brown.	2
	Obed Till (unoxidized)	
3	Till, dark grey, dense, clayey, moderately stony; stones 1/8" to 2' diameter; typical Cordilleran erratic composition (slope is artificially terraced, observe largest part of section).	142
	Pedley Sediments	
4	Sand, medium grained, moderately sorted, some gravel lenses; well bedded, mainly horizontal bands 6" to 10" thick. Some ill- defined cross beds; upper and lower contact not exposed. This unit partly covered.	55+
	Total	200+

Section Name: Marlboro
Section No. 187

Surface Form: Ground Moraine
Location: SW 1/4 Sec. 36, Tp. 52, R. 20 W5

Unit No.	Lithology Description	Thickness (Feet)
Marlboro Till (type section)		
2	Till, dusky yellow to pale olive, sandy, silty matrix; nonplastic; moderately stony, cobbles up to 6", mode 1"; pebbles composed of limestone, subangular to subrounded; weathered colour yellowish grey. Till forms surficial deposit in this area.	20.5
Paskapoo formation		
1	Shale and lithic sandstone, interbedded	-
Total		20.5

Section Name: Trail Creek
 Section No. 188

Surface Form: Drumlin
 Location: SW 1/4 Sec. 3, Tp. 52, R. 24 W5

Unit No.	Lithology Description	Thickness (Feet)
Aeolian		
23	Sand, very fine to fine grained, rusty brown podzol soil.	2 - 3
Obed Till		
22	Till, yellowish grey, very stony, mode 3/4" diameter, subangular to subrounded; very sandy clay matrix, numerous sand lenses of Unit No. 21 in base of till - some contortions (periglacial ?); pebbles coated with CaCO_3 , lime bands common.	4.5
Outwash		
21	Sand, dusky yellow, fine to medium grained, rare pebble up to $1\frac{1}{2}$ " diameter; poorly bedded, minor silty bands and coal fragments, gradational lower contact.	3.5
20	Silt, dusky yellow, sandy, slightly clayey, un- bedded; gradational lower contact.	6.0
19	Sand, dusky yellow, fine to coarse grained, rare pebbles, poorly sorted, subangular to subrounded, vaguely bedded; 5 to 10% pebbles at top, rare	

Section No. 188 cont.

silty clay band; sharp lower contact. 4.0

Obed Till (type section)

18 Till, dusky yellow to moderately olive brown
(oxidized zone), otherwise as for Unit No. 17;
Unit No. 18 most resistive - cliff former. 9.5

17 Till, olive black, silty, sandy clay matrix,
moderately plastic; very stony, pebble to cobble;
mode 1 - $1\frac{1}{2}$ " diameter, up to 3', subangular to
subrounded; contact with underlying unit irregular
but distinct; part of till projects into sand. 6.5

Pedley Sediments (type section)

16 Sand, fine to coarse grained, poorly sorted, dusky
yellow, some pebble bands, minor clay and silt bands. 3.0

15 Silt, clayey, as for Unit No. 13. 3.5

14 Sand, fine to coarse grained, poorly sorted,
vague cross beds and bands. 2.5

13 Silt, dusky yellow, slightly sandy, vaguely
laminated; gradational contact with lower unit. 1.5

12 Sand, very fine grained, grading to silt at top;
light dusky yellow; short discontinuous wavy
laminations, small scale cross beds (dip 26° at 075);
irregular gradational contact with lower unit. 3.3

Section No. 188 cont.

- | | | |
|----|---|-----|
| 11 | Till, moderate olive brown, very sandy clay matrix, very stony, up to 3' diameter, subangular-subrounded, numerous limestone, quartzites; lower contact sharp. | 4.3 |
| 10 | Sand, dusky yellow, very fine grained vaguely laminated, some minor contortions; thins to 4' toward west - may be lense; gradational lower contact. | 6.5 |
| 9 | Gravel; 75% framework, 25% matrix of fine to medium grained sand; 1½" diameter, subrounded to subangular; numerous limestone, quartzite, some sandstone; unbedded; sharp contact with underlying till. | .3 |
| 8 | Till, moderate olive brown, as for unit 6. | 2.7 |
| 7 | Sand, dusky yellow, weathered yellowish grey, very fine grained to silt; rare pebble to cobble "floating" in sand (quartzite, sandstone, limestone up to 6" long); vaguely laminated; contact with unit 6 irregular and sharp; sand is continuous across outcrop. | 2.2 |

Marlboro Till

- | | |
|---|--|
| 6 | Till, dusky yellow to moderate olive brown; very |
|---|--|

Section No. 188 cont.

	sandy clay matrix; very stony, mode $1\frac{1}{2}$ " diameter, up to 2' subangular-subrounded, some pebbles and cobbles broken (sharp angular faces); sharp contact with underlying sand band.	5
5	Till, light olive grey; silty, sandy clay matrix, moderately plastic; very stony, mode $1\frac{1}{2}$ " diameter, up to $1\frac{1}{2}$ ' subrounded to subangular, rare rotten quartzite boulders; gradational lower contact; 3" discontinuous pebble sand band at top.	6.5
4	Till, light olive grey; silty, sandy clay matrix, slightly plastic; very stony, mode $1\frac{1}{2}$ " diameter; gradational lower contact.	5.5
3	Till, as above but stony, some rotten quartzite boulders; transitional with unit 2.	5
2	Till, olive brown, matrix stony, mode $\frac{1}{2}$ " to 2" diameter, up to 3', mainly angular local sandstone, some limestone, rare quartzite.	3
Paskapoo Formation (Paleocene)		
1	Sandstone, lithic.	-
Total		95.4

Section Name: Barbara Creek
 Section No. 200

Surface Form: Valley Train
 Location: NW 1/4 Sec. 1, Tp. 54, R. 26 W5

Unit No.	Lithology Description	Thickness (Feet)
	Outwash	
3	Surrounding this section is typical Cordilleran outwash deposits which overlie till of this section.	0 - 20
	Obed Till and Glaciolacustrine Deposits	
2	Till - yellowish grey (dry) to olive grey (wet) moderately stony, striated limestone numerous, quartzites common, subangular - subrounded, mode 1" to 5" diameter, up to 2'; matrix very clayey, slightly silty, very hard, numerous shrinkage cracks; distinctly bedded due to 6" band of clay - clay bed displaced 5" (small normal fault - south side up relative to north side), contains scattered pebbles.	7
	Outwash	
1	Gravels - pebble to cobble, mode $\frac{1}{2}$ " to 3" diameter, up to 1', 75% framework, 25% matrix, subangular-subrounded pebbles; no visible bedding, numerous limestone and quartzite, some limestone striated; matrix medium olive brown, slightly clayey sand; slightly cemented (CaCO_3) - probably ice-contact deposits.	11 - 40
	Total	18 - 67+

Section Name: Pembina River
Section No. 210

Surface Form: Drumlin
Location: SW 1/4 Sec. 17, Tp. 48, R. 16 W5

Unit No.	Lithology Description	Thickness (Feet)
----------	-----------------------	------------------

Outwash Gravel

- | | | |
|---|---|----|
| 5 | Soil profile - sand, some pebbles; podzol-top bank - 200 yards to the west following outwash gravel overlies till of Unit No. 3. | 2 |
| | Gravel, mode 1 to 2" diameter, up to 8", round to subround, 25% matrix fine - medium olive brown sand, well sorted; pebble composition different from gravels of Unit No. 2 - variety of quartzites, some pink granites (1 - 2%), fair bedding. | 21 |

Raven Creek Till

- | | | |
|---|--|----|
| 3 | Till, dark yellow brown to moderate olive brown, matrix sandy clayey silt, slightly plastic, high dry strength; very stony mode 1 3/4" diameter up to 2', all Cordilleran pebbles but granitic erratics common in till of general vicinity, numerous limestone; sharp lower contact. | 17 |
|---|--|----|

Outwash

- | | | |
|---|---|--|
| 2 | Gravel, pebble mode 1/2" diameter up to 6", subrounded, mainly medium grey limestone, some pink and light grey quartzite and sandstone; 20% | |
|---|---|--|

Section No. 210 cont.

fine to medium grained sand matrix; well
bedded, lower 4' mode of gravel is 3" diameter,
up to 10" with rare sand bed - this unit is very
continuous along Pembina River.

16

Paskapoo Formation

1 Sandstone, friable; contact with drift 50' above
river.

-

Total

56

Section Name: Oil Well Site
Section No. 223

Surface Form: Drumlin
Location: SW 1/4 Sec. 26, Tp. 51, R. 15 W5

Unit No.	Lithology Description	Thickness (Feet)
----------	-----------------------	------------------

Mixed Till (type section)

2	Till, medium olive brown, very plastic, slightly sandy; moderately stony, up to 1.5' diameter, mode 3/4", subangular to angular, some subrounded; numerous metaquartzites, orthoquartzites, limestone and several varieties of granite.	4.5
---	---	-----

Paskapoo Formation

1	Shale and lithic sandstone, interbedded.	-
Total		4.5

Section Name: Raven Creek
Section No. 229

Surface Form: Drumlin
Location: SE $\frac{1}{2}$ Sec. 7, Tp. 50, R. 16 W5

Unit No.	Lithology Description	Thickness (Feet)
----------	-----------------------	------------------

Raven Creek Till (type section)

2	Till, greenish grey to brownish grey, slightly plastic, sandy matrix; moderately stony, pebbles orientated in north-south direction, up to 10" diameter, mode 1"; numerous orthoquartzites, meta-quartzites, lithic sandstone, rare granite and lime-	
---	---	--

Section No. 229 cont.

stone. Laminated clay bed in upper two feet

with $\frac{1}{2}$ " of marl at bottom.

5

Paskapoo Formation

1

Lithic sandstone, soft

-

Total

5

Section Name: Sundance Creek
Section No. 232

Surface Form: Delta
Location: SE 1/4 Sec. 8, Tp. 53, R. 19 W5

Unit No.	Lithology Description	Thickness (Feet)
	Marlboro Delta	
	Soil profile, weakly developed podzol.	1.5
1	Sand, light greyish brown, lithic, very fine to fine grained, well sorted, distinctly laminated, some small scale cross strata, trend 110, dip 16°; laminae defined by coal fragments. At bottom of unit 1/4" thick marl band, at least 3' long.	2.4
2	Sand, light greyish brown, lithic, fine to medium grained; medium scale cross strata, part of a large foreset (?), trend 045°, dip 28°; upper 1' shallower dip and is laminated fine grained sand with rare 1/4" pebble bands and coal fragments; gradational contact with overlying unit.	2.6 - 4.0
3	Sand, light greyish brown, very fine grained, silty; distinct cross-laminae, marked by fine grained coal fragments; scattered subrounded cobbles of plastic, light brown clay, up to 12" diameter - appears to be matrix supported; clay is identical in appearance to clay of Unit 4; upper contact gradational.	2.2

Section No. 232 cont.

4	Clay, light brown; numerous irregular sand lode casts in lower part; upper part disturbed; transitional upper contact.	1
5	Sand, light greyish brown, lithic; fine to medium grained, medium scale, high angle cross-strata; interbedded with 3 - 4" thick bands of fine to medium grained lithic sand; cross strata 6 - 7" thick, trend 154, dip 34°; some beds defined by coarse coal fragments up to 2" in diameter. Contact with underlying unit gradational; upper contact irregular, marked by ?lode casts.	5
6	Sand, light greyish brown, very fine to fine grained, moderately well sorted; numerous distinct cross laminae; dense; porous; underlying unit not exposed.	2
Total		16.7 - 18.1+

Section Name: Gallaway
Section No. 238

Surface Form: Ground Moraine
Location: SE 1/4 Sec. 34, Tp. 52, R. 20 W5

Unit No.	Lithology Description	Thickness (Feet)
----------	-----------------------	------------------

Obed Till

11	Sand, poorly sorted fine to medium grained, some gravel bands; podzol soil; lower contact marked by irregular bands of pebbles.	2
10	Till, light olive brown, very stony, 1½" mode, up to 18" diameter, subrounded to angular; matrix very sandy; appears bedded in places; numerous distorted sand beds and lenses in lower 4' of till - sand partly weathered out leaving cavities, ?periglacial structures; lower contact irregular.	10

Marlboro Delta

9	Gravel as above but no sand beds; sharp lower contact.	2 - 4
8	Gravel, pebble to cobble size, poorly sorted, mode 1½" diameter up to 8", angular to subangular, few limestone, numerous quartzites and local bedrock fragments; cross laminations of fine grained sand in upper 1' ; matrix 20% very fine grained silty sand; poorly bedded; undulating lower contact.	4

Section No. 238 cont.

- | | | |
|---|---|-----|
| 7 | Sand, medium olive brown, very fine to fine grained, obscure cross - laminations and bands with rare pebbles; interbedded with medium grained sand - frequently 3" to 4", gradational contact. | 8 |
| 6 | Gravel, pebble to cobble size, mode 1" diameter up to 1', subangular; 20% matrix of coarse grained sand; poorly sorted; sharp lower contact. | 4.5 |
| 5 | Sand, medium brown, silty, slightly clayey, very fine grained; minor 3" bands of cross bedded medium grained sand; poorly exposed; gradational lower contact. | 4 |
| 4 | Sand, medium brown, medium coarse grained, lithic, moderate sorting, some bands with pebbles; small - medium scale cross strata, trend 150, dip 5 to 10°, laminated and banded in lower part, gradational with underlying unit. | 5.5 |
| 3 | Sand, medium brown, silty, very fine grained, vague laminations and ?cross-laminations, sharp lower contact. | 6 |
| 2 | Silt, clayey, dark olive brown, very dense, laminated, gently undulating laminated beds | |

Section No. 238 cont.

form deep troughs 5' long and 3' deep, festoon -
like; clay content increase towards base.

10

Paskapoo Formation

1

Shale

-

Total

56 - 58

Section Name: Obed Lake
Section No. 239

Surface Form: Drumlin
Location: SE 1/4 Sec. 9, Tp. 53, R. 22 W5

Unit No.	Lithology Description	Thickness (Feet)
----------	-----------------------	------------------

Obed Till (ablation till?)

1	Soil profile, poorly exposed - podzolic.	2
2	Till, as for Unit No. 3 but more stones and lighter in colour, mode of stone 2" diameter up to 2', some local shale and sandstone fragments, but mainly Cordilleran erratics; good variety of quartzites.	5 (varies 2 - 8 laterally)

Obed Till

3	Till, moderate olive brown, clayey to sandy matrix, moderately plastic, moderate dry strength, friable, pebbles 20%, mode 1" diameter up to 2' upper contact gradational, lower contact obscure but appears undulatory. Minor discontinuous fine grained lithic bands throughout till. Erratics of Cordilleran origin.	6
---	---	---

Pedley Sediments

4	Silt, dark olive brown, very thin bedded, continuous laterally for at least 60 yards some very fine grained sand bands; saturated, ground water	
---	---	--

Section No. 239 cont.

seepage. Some laminations, composed of alternating bands of silt and very fine contact with underlying till abrupt and distinct; upper contact obscure but appears undulatory.

2 - 3

Marlboro Till

- 5 Till, olive grey, very clayey, slightly sandy; plastic moderate to high dry strength; 15% pebbles, mode 3/4" diameter up to 1", subrounded to subangular, mainly quartzites, some limestone; thin layer of colluvium obscures gross aspect; thickness varies from 4' to 12' laterally over 100 yards. Underlying unit not exposed. Erratics of Cordilleran origin.

7

Total

81 - 91

Section Name: Hanlan Creek
 Section No. 243

Surface Form: Ground Moraine
 Location: NW 1/4 Sec. 11, Tp. 49, R. 18 W5

Unit No.	Lithology Description	Thickness (Feet)
	Marlboro Till	
1	Soil profile	1.2
2	Till, light olive grey, weathers to very light brown; silty, slightly sandy matrix, plastic; breaks into angularly blocks, pebbles 10 - 15%, mode 1" diameter up to 2'; limestone not common, locally absent; erratics all of Cordilleran origin; overlies sandstone and shale; lower part of till with abundant fragments of underlying bedrock; minor sand lense in lower part of till.	13
	Paskapoo Formation	
3	Sandstone and shale	-
	Total	14.2

Section Name: Plante Creek
Section No. 246

Surface Form: Lacustrine Plain
Location: NE 1/4 Sec. 1, Tp. 54, R. 23 W5

Unit No.	Lithology Description	Thickness (Feet)
	Obed Till	
12	Soil profile, sandy silt.	3
11	Till, moderate, olive grey, moderately stony, mode 1" to 3/4" diameter up to 2', mainly quartzite, limestone and sandstone, very sandy clay matrix; undulating sharp contact with underlying unit; thickness not uniform (6" to 2"); small contorted stringer of sand in upper part.	1.2
10	Sand, buff, fine grained, well sorted, bedding obscure.	1.5
9	Clay and fine grained sand interbeds.	1.5
8	Sand, light grey, fine grained, well sorted; bedding obscure, vague small scale low angle cross strata	2.4
7	Till? olive grey to olive brown, sandy clay matrix; moderately plastic, moderate dry strength, stony, mode 3/4" diameter up to 8", subangular - subrounded; pebbles, limestone, quartzite, sandstone mainly; abrupt lower and upper contact; lenses out after 40', ? mudflow.	0 - 6

Section No. 246 cont.

Plante Creek Sediments

- | | | |
|---|--|----|
| 6 | Sand, very fine grained, well sorted, light grey, rare band of clay; vague medium to large scale cross strata. | 11 |
| 5 | Clay, dark grey to olive brown, silty, very plastic, high dry strength, banded in upper part, gradational contact with overlying unit; rare pebble "floating" in clay. | 2 |
| 4 | Sand, very fine grained, light grey, bedding obscure; 6" clay band, undulating. | 9 |
| 3 | Interbedded clay and sand, frequency 4 - 5" clay to 2' sand. Clay, dark grey, vague bedding; sand, very fine grained, well sorted, pale yellowish brown, banded (1/4"), contact between sand and clay sharp. | 4 |
| 2 | Clay, dark grey, silty and slightly sandy, banded, some bands with minor contortions; minor interbeds of sand (groundwater coming out of sand interbeds). | 7 |

Marlboro Till

- | | |
|---|---|
| 1 | Till, dark grey, sandy, silty clay matrix, indurated, massive, high dry strength; |
|---|---|

Section No. 246 cont.

moderately stony, mode $1\frac{1}{2}$ " diameter up to
 3', mainly quartzites, limestone rare, sub-
 angular - subrounded pebbles vaguely lineated.
 Appears to grade into sand above and laterally -
 contact may be erosional in part - not exposed.
 Necessary to move 40 yards to east to resume
 measurement so possible error in correlation
 although appears reasonable. Lower contact not
 observed.

26

Total

68.6 - 74.6+

Section Name: McLeod Bridge
Section No. 262

Surface Form: Ground Moraine
Location: NW 1/4 Sec. 20, Tp. 53, R. 16 W5

Unit No.	Lithology Description	Thickness (Feet)
----------	-----------------------	------------------

Glaciolacustrine Sediments

7	Soil profile - grey wooded?	
6	Clay, light medium grey, banded, silty, some mottles of medium brown, highly plastic, high dry strength.	5.5
5	Sand, very fine grained, silty and clayey, medium olive brown, well bedded, cross-laminated; bands 1" - 2", slightly wavy; gradational contact with Unit No. 4	5
4	Clay, medium grey, laminated, well bedded, highly plastic, some silt and very fine sand in laminae and bands (? graded); abrupt lower contact with till.	20

Edson Till

3	Till, dark olive grey to olive brown; sandy, silty clay matrix; high plastic, high dry strength, hackly on dry surface; moderately stony, mode 2" diameter up to 4'; most boulders creamy and light grey quartzite, some granite, rare limestone, subrounded-subangular; stoniness count 97.	20
---	--	----

Section No. 262 cont.

2	Till - as for Unit No. 3 but mostly covered by recent slump.	19
---	--	----

Paskapoo Formation

1	Sandstone bedrock	
---	-------------------	--

Total	69.5
-------	------

Section Name: Lowland
Section No. 263

Surface Form: Ground Moraine
Location: SE 1/4 Sec. 26, Tp. 54, R. 16 W5

Unit No.	Lithology Description	Thickness (Feet)
----------	-----------------------	------------------

Glaciolacustrine Sediments

1	Clay, yellowish grey, calcareous, irregular contact with till, clay occurs in patches locally, occupying depression in till surface; grey-wooded soil profile.	1 - 2
---	--	-------

Edson Till

2	Till, dark olive brown, plastic, high dry strength; moderately stony, mode 1" diameter, up to 2', metaquartzite and crystalline rocks (granite, etc.) common.	2.5
---	---	-----

Lowland Gravel

3	Gravel, 60% pebbles, mode 1" diameter, up to 6", subangular to subrounded, poorly sorted, unbedded; pebbles mainly metaquartzite, chert, local bedrock; matrix fine to coarse grained quartz sand, clayey; strongly iron-stained in upper 6", irregular contact with overlying till.	2 - 3
---	--	-------

Section No. 263 cont.

Paskapoo Formation

4	Sandstone, pale yellowish green, lithic, soft, bentonitic.	-
Total		5 - 7.5

Section Name: Rosevear
Section No. 265

Surface Form: Lacustrine Plain
Location: SW 1/4 Sec. 21, Tp. 54, R. 15

Unit No.	Lithology Description	Thickness (Feet)
Glaciolacustrine Sediments		
1	Soil profile, very fine to fine grained sand and silt; bottom contact with underlying clay abrupt.	1.0
2	Clay, silty, light yellowish brown to moderate olive brown, moderately plastic, 1/8 to 1/4" bands (?varves); bottom contact with till gradational.	1.2
Edson Till (type section)		
3	Till, medium olive brown to dark olive brown, stone poor, pebble mode 1 1/2" diameter up to 14"; subrounded to subangular, some quartzites, sandstone, siltstone and granitic rocks of Shield origin; matrix silty clay, moderately plastic.	10.5
Paskapoo Formation		
4	Bedrock, interbedded sandstone and shale.	-
Total		12.7

Section Name: McLeod River
Section No. 269

Surface Form: Lacustrine Plain
Location: NE 1/4 Sec. 12, Tp. 52, R. 19 W5

Unit No.	Lithology Description	Thickness (Feet)
Glaciolacustrine Sediments (type section)		
6	Soil profile.	1.5
5	Clay, silty, light bands (1/4 - 1/16") alternating light brown to very light brown, bands undulating slightly, uniform laterally (?varves).	10
4	Sand, very fine grained, medium brown-light brown, well bedded (banded), cross laminations, numerous in upper 2' (2" thick and 4" long - easterly dip); some clay bands up to 1' thick.	12
3	Clay, bluish grey, silty, massive, dense, poorly exposed.	12
2	Sand, poorly exposed, very poorly sorted, minor gravel lenses; banded.	6
Marlboro Till		
1	Till, medium grey, silty, sandy clay matrix; very dense; moderately stony, all Cordilleran lithologies; mode 3/4" diameter up to 1', subangular; some of section obscured by mud flows - assume till to below river level.	60
Total		101.5+

Section Name: Oldman Creek
Section No. 271

Surface Form: Ground Moraine
Location: NW 1/4 Sec. 13, Tp. 55, R. 23 W5

Unit No.	Lithology Description	Thickness (Feet)
----------	-----------------------	------------------

Marlboro Till

- | | | |
|---|--|---------|
| 1 | Till, olive brown to olive grey, stony, typical Cordilleran erratics; numerous sandstone bedrock fragments in places, some sand lenses; small pink granite pebbles in upper 6', quartzite-hornblende gneiss found in lower part - these are very rare. | 25 - 30 |
|---|--|---------|

Marsh Creek Outwash (type section)

- | | | |
|---|---|----|
| 2 | Mainly pebble gravel, some till interbeds? outcrop poorly exposed due to thin layer of mud flow on the surface; quartzites very common, limestone rare, some granitic pebbles; may be ice contact unit. | 20 |
|---|---|----|

Marsh Creek Till (type section)

- | | | |
|---|---|-----|
| 3 | Till, medium grey dese sandy clay matrix, stony, mode $\frac{1}{2}$ " diameter up to 4" granitic pebbles common; lower contact obscure - this is only a small outcrop 30 feet above creek - appears to continue below level of creek. Abrupt contact with overlying gravel. | +35 |
|---|---|-----|

Total

80 - 85+

Section Name: Wildhay River
Section No. 273

Surface Form: Outwash Plain
Location: NE 1/4 Sec. 27, Tp. 57, R. 23 W5

Unit No.	Lithology Description	Thickness (Feet)
	Outwash - ?Deltaic	
6	Podzol profile, sand	1 - 2
5	Sand, medium brown, silty, fine grained well sorted, rare scattered "floating" pebble; cliff-former.	6
4	Sand, fine grained, lithic, well sorted, medium grey; abrupt lower contact; no visible bedding.	12
3	Clay, medium dark grey, silty, highly plastic, scattered pebbles in upper part up to 3" long; undulating contact with Unit Nos. 2 and 4.	2 - 6
2	Sand, medium brown, grey, fine grained, fair sorting, well bedded, 1/4" - 1/2" bands, coal fragments in bands; unit occupies trough eroded in underlying till.	
	Edson Till	
1	Till, dark olive brown, sandy and silty clay matrix, highly plastic, high dry strength; stony, mode 3/4" diameter up to 2', subangular to subrounded, variety of quartzites, limestone rare, some granitic rocks;	

Section No. 273 cont.

contact with overlying unit irregular, probably
erosional.

5 - 40

Total

66 - 101

Section Name: Edson River

Surface Form: Cutbank in Glaciolacustrine
plain, gently rolling.

Section No. 278

Location: SE 1/4 Sec. 27, Tp. 57, R. 23 W5

Unit No.	Lithology Description	Thickness (Feet)
Glaciolacustrine Sediments		
1b	Silt, clayey, calcareous, banded.	7
Edson Till		
1a	Till, medium brown, highly iron stained, appears bedded from a distance, minor contorted lenses of gravel; erratics of Shield origin.	
2a	Till, bedded shale, sandstone, coal, fractured but continuous laterally for at least 50 feet; thin layer of brownish grey till occurs in middle of unit.	12
2	Till, as for Unit 5 but with numerous pockets of "bedrock" (shale, sandstone and some coal); in irregular masses within till.	10
3	Till, medium grey, hard, plastic, unoxidized; stone poor, pebble mode $1\frac{1}{2}$ ", up to 1'; massive; 6" lense of yellowish grey clayey sand; granitic and high grade metamorphic erratics common.	12

Section No. 278 cont.

Buried Valley Gravel

- 4 Gravel, pebble mode 2", up to 4", 20% fine to coarse sand, some laminated medium grained sand lenses, generally thin bedded; pebbles elongated and tabular, subrounded; pebble imbrication 21° to 28° dip, 331 azimuth; pebble lithology mainly metaquartzites, quartzites, quartzitic sandstones, feldspathic sandstones, limestone. 6 - 8

Paskapoo Formation

- 5 Sandstone, 4' above river level.

Total

37 - 39+

PLATES 1 to 28

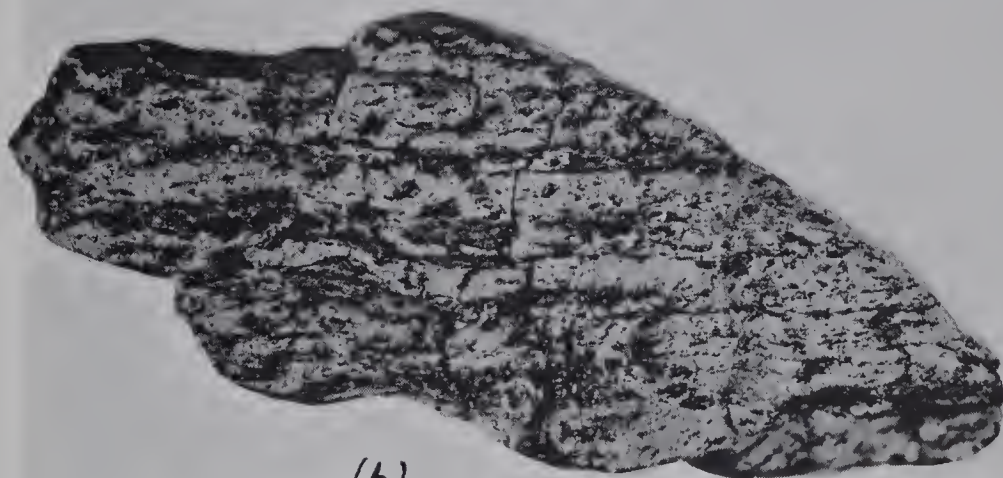
Locations of plates and the directions
in which photographs were taken are
shown in Figure 11.

Plate 1. Some cobbles of the Athabasca Valley Erratics
Train

- (a) Garnet schist, locality no. 5, Figure 5
- (b) Biotite quartz schist, locality no. 5, Figure 5
- (c) Hornblende garnet quartz gneiss, locality no. 4,
Figure 5



(a)



(b)



(c)

Plate 2. View of Athabasca River looking upstream
towards the west

The river channel in this general area (Sec. 22,
Tp. 54, R. 22 W5) was eroded in Recent time to
a depth of 250 feet below the general level of
the Athabasca Benchland.



PLATE 2

Plate 3. Lateral Moraine

Lateral moraine in Edson till on the north side of Mayberne Tableland and ground moraine of Mayberne till overlying Pleistocene-Tertiary terrace. North-facing scarp is typical of the high terraces of Mayberne Tableland and the meltwater channels are also characteristic.

Location of photograph is in Tp. 58, R. 19 W5.

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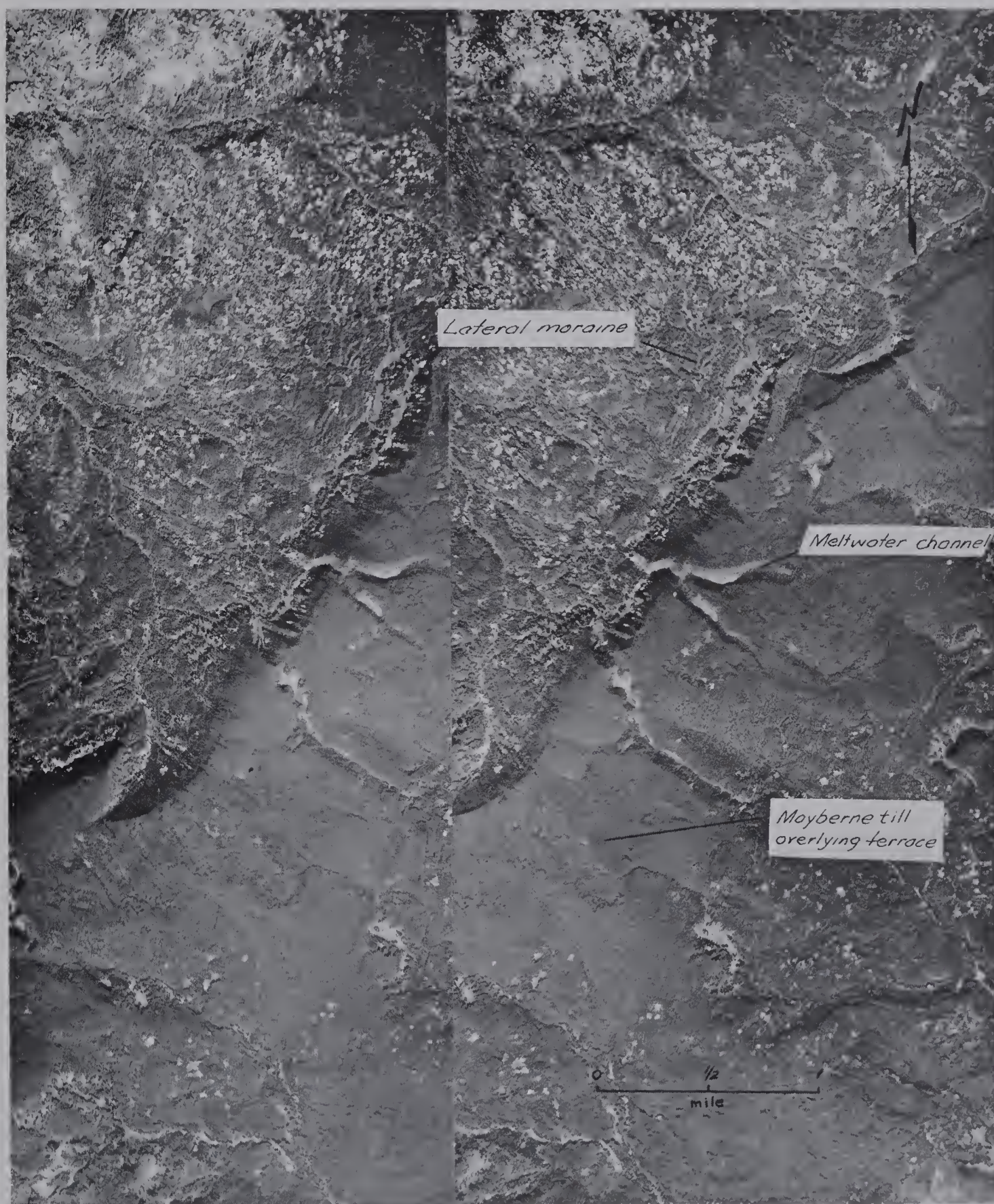


PLATE 3

Plate 4. Mayberne Tableland and Edson Benchland

View looking east from Mayberne Fire Tower showing Pleistocene-Tertiary terrace levels of Mayberne Plateau and remnant benches of Edson Benchland.

Note the general slope to the north of terrace level II and steep south facing scarp marking boundary between Edson Benchland and Mayberne Tableland.

Plate 5. Lowland Gravel

Typical deposit of Lowland gravel overlying bentonitic sandstone of the Paskapoo Formation and underlying Edson till in the Edson Lowland. Gravel has been disturbed by overriding glacier at this locality.



PLATE 4



PLATE 5

Plate 6. Mayberne Tableland

View looking west across the Mayberne Tableland from Mayberne Fire Tower showing Pleistocene-Tertiary terrace levels. Very gentle slope to the north is noticeable in both terrace levels.



PLATE 6

Plate 7. "Circles"

"Circles" marked by a light band of vegetation in Obed till, Tp. 52, R. 25 W5. Till is less than ten feet thick in northern part of photograph and most of the relief is due to irregular bedrock surface of the Brazeau Formation.

(Reproduced with the permission of the National Air Photo Library)



PLATE 7

Plate 8. Moulin Kame

Detail of complex structure in moulin kame overlain by a thin layer of till (till not shown in photo). Structure is an anticline the limbs of which exhibit chevron-like parasitic folds; the anticline has also been affected by normal, reverse, and thrust faults.

Plate 9. Pitted Outwash Deposit

Gravel pit immediately south of Jarvis Lake exposes complex sedimentary structure in part of pitted outwash map unit. Pebble gravel, bedded sand and clay, all somewhat contorted, occur in this unit.



PLATE 8



PLATE 9

Plate 10. Hinton Terrace, Upper and Lower Units

Photo shows the upper and lower units of outwash gravel which comprises the lowermost terrace of the Hinton Terraces. Upper unit displays parallel bedding and overlies the lower unit disconformably. The lower unit is distinctly cross-stratified.

Plate 11. Hinton Terrace, Upper Unit

Parallel bedding in detail is difficult to detect in upper unit (turn sideways for upright view of photo). Small patches of this gravel display openwork framework, but this is a poor example.



PLATE 10



PLATE 11

Plate 12. Glaciolacustrine Sediments

Banded or varved (?) calcareous clay of glaciolacustrine sediments overlying Edson till shown in the photograph is typical of much of the Edson Lowland.

Plate 13. Pebble Band, Glaciolacustrine Sediments

Residual pebble band deposited during initial "transgression" of glacial lake water. Pebbles were derived by reworking of underlying Edson till. Gently undulating topography of Edson Lowland in background.



PLATE 12



PLATE 13

Plate 14. Pebble Band, Glaciolacustrine Sediments

Close-up photo of area shown in Plate 13. Note the grey wooded soil profile developed on silty clay of glaciolacustrine sediments.

Plate 15. Mayberne Till

Deposit of stony Mayberne till in the Mayberne Tableland is about 3 feet thick at this locality. Crystalline rocks of Canadian Shield origin are extremely rare in this part of the area; metaquartzite is the main pebble (?) lithologic type. See sample no. 268 for laboratory analysis of deposit shown in this photograph.



PLATE 14



PLATE 15

Plate 16. Lobate End Moraine

Stereo-pair of lobate end moraine and hummocky dead-ice moraine composed of Marlboro till. Note the northwest trending till ridges which intersect the lobate end moraine. These disintegration features are located about 10 miles to the south of the terminal moraine of a northern lobe of the Marlboro glacier. Location of photo is Tp. 54, R.25 W5.

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PLATE 16

Plate 17. Obed Till

A typical outcrop of Obed till (sample #179) occurring in lateral moraine on the north side of the Athabasca Benchland. This outcrop has been destroyed since the photograph was taken.

Plate 18. Obed Till

Close-up of Obed till of Plate 18 showing very stony texture which is typical of the till.



PLATE 17



PLATE 18

Plate 19. Clay - Pedley Sediments

Very plastic clay included in the Pedley sediments.

Note contorted laminations and fault structure, both of which may be due to overriding of Obed glacier.

This is the kind of sediment underlying the lower Hinton Terrace near the paper plant of North Western Pulp and Power Ltd.



PLATE 19

Plate 20. Outwash Sand

A good example of climbing ripples preserved in outwash sand of the Wildhay Benchland. Current direction was from left to right (towards the north).

Plate 21. Outwash Sand

Planar bedding in fine grained sand forming part of the outwash sand deposits of the Wildhay Benchland. This outcrop is adjacent some ice-contact gravel deposits which may explain the minor reverse and normal faultings in the sand.



PLATE 20



PLATE 21

Plate 22. Outwash Gravel

Easterly dipping outwash gravel, some of which is classified as openwork gravel, is common in the area west of Entrance associated with an end moraine of the Obed glacier. Aeolian sand, containing several charcoal-rich dark bands overlies the gravel with sharp angular unconformity. Pebbles are coated with calcium carbonate to a depth of at least ten feet below the surface at this locality.

Plate 23. Outwash Gravel

Steeply dipping beds of outwash gravel in same unit as Plate 22. Note the shallow dip to the left; a dip reversal of the same gravel bed actually occurs at this outcrop. Charcoal rich bands in aeolian sand are very distinct in this photo. Radiocarbon date on charcoal at this locality indicated an age of $1,300 \pm 95$ years B.P. for the upper part of the sand.



PLATE 22



PLATE 23

Plate 24. Beach Deposit - Glaciolacustrine Deposits

One to two feet of pebble gravel occurring in a narrow band below glaciolacustrine clay and above the Edson till is shown in the photo. This is the only beach deposit recognized in the area.



PLATE 24

Plate 25. Marlboro Delta

Two sets of large scale high angle planar cross strata dipping to the east occur at this locality, but only one is recognizable in this photo. The photo is taken from Highway 16 and is typical of the stratification of foreset beds in the main part of the Marlboro delta. Gentle, smooth topographic outline is typical of the delta deposit.

Plate 26. Marlboro Delta

Photo shows detail planar bedding of pebbly sand shown in the right side of Plate 8. The sand is of economic value as pit-run granular fill and is presently being excavated at an alarming rate; at least part of this locality should be preserved since it is a classic example of deltaic foreset bedding.



PLATE 25



PLATE 26

Plate 27. Blowout in Aeolian Bedded Sand

Blowout in active sand dune area on east side of Brule Lake exposes very large scale coset of low angle cross strata. Note the curved contact between sets at man's midsection indicating trough type classification of cross strata. Photo taken looking north.

Plate 28. Aeolian Bedded Sand, Brule Lake

Outcrop of aeolian sand on the east side of Brule Lake to the lower right of Plate 27. Photo illustrates gradual inclination of cross strata set towards the left. Direction of wind which is inferred to have formed this deposit was from left to right since this is by far the dominant prevailing wind direction at present.



PLATE 27



PLATE 28

Four charts in pocket



QUATERNARY
RECENT

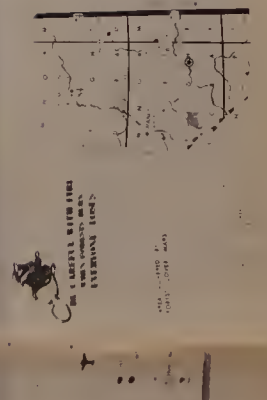
- 21 Gravel
- 20 Clay silt and sand
- 19 Dark silty clay
- 18 Dark silty clay
- 17 Dark silty clay
- 16 Dark silty clay
- 15 Dark silty clay
- 14 Dark silty clay
- 13 Dark silty clay
- 12 Dark silty clay
- 11 Dark silty clay
- 10 Dark silty clay

LEGEND

- 1 Continental shelf
- 2 Continental shelf
- 3 Continental shelf
- 4 Continental shelf
- 5 Continental shelf
- 6 Continental shelf
- 7 Continental shelf
- 8 Continental shelf
- 9 Continental shelf
- 10 Continental shelf
- 11 Continental shelf
- 12 Continental shelf
- 13 Continental shelf
- 14 Continental shelf
- 15 Continental shelf
- 16 Continental shelf
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- 1 Continental shelf
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- 21 Continental shelf

WEST OF THE FIFTH MERIDIAN





LOWEST AND HIGHEST

WEST OF THE FIFTH MERIDIAN

SCALE 1" = 1 MILE

UNCLASSIFIED 1:12

1. 1000' 2. 2000' 3. 3000' 4. 4000' 5. 5000' 6. 6000' 7. 7000' 8. 8000' 9. 9000' 10. 10000'

1. 1000' 2. 2000' 3. 3000' 4. 4000' 5. 5000' 6. 6000' 7. 7000' 8. 8000' 9. 9000' 10. 10000'

1. 1000' 2. 2000' 3. 3000' 4. 4000' 5. 5000' 6. 6000' 7. 7000' 8. 8000' 9. 9000' 10. 10000'

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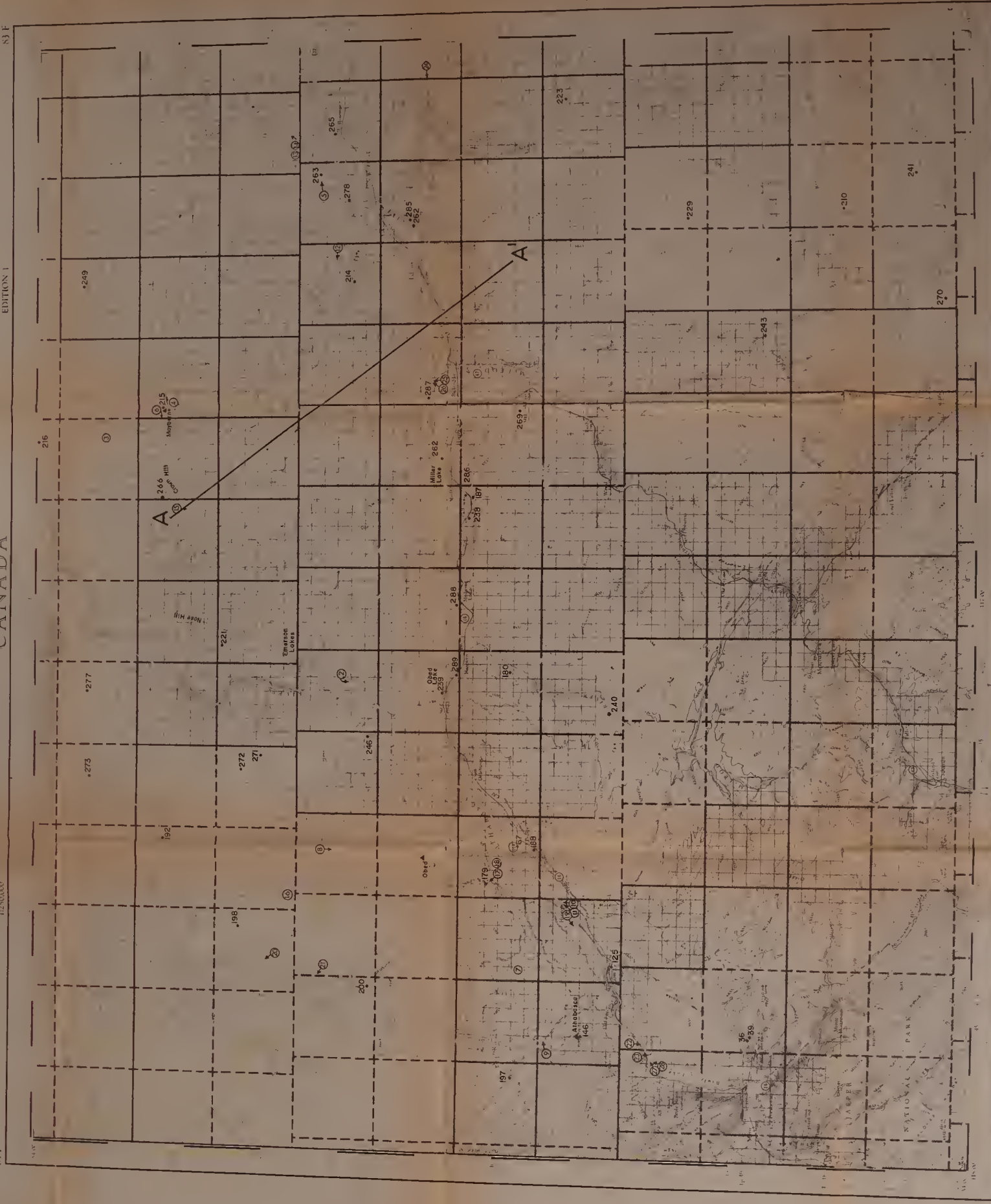


FIGURE 11

LOCATION MAP EDSON-HINTON AREA

Showing Location of Stratigraphic Sections (272, 273, 277), Plates (272, 273, 277), Direction of Plates (→), and Location of Topographic Cross-Section A-A'.

Contour Interval 200 and 500 Feet, Elevation in Feet Above Mean Sea Level

0 miles 4

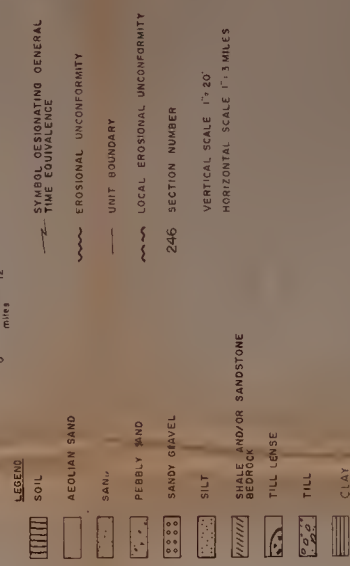
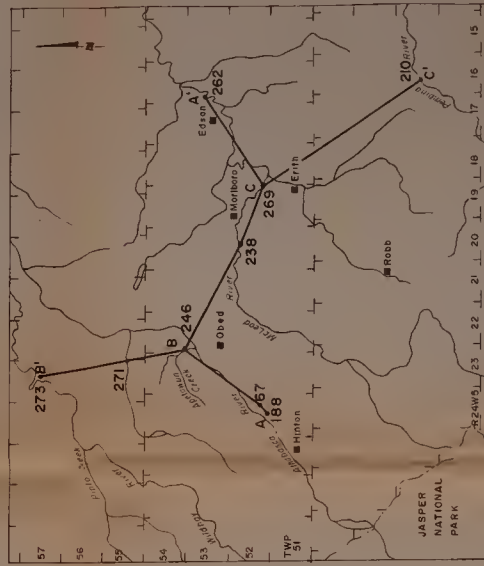
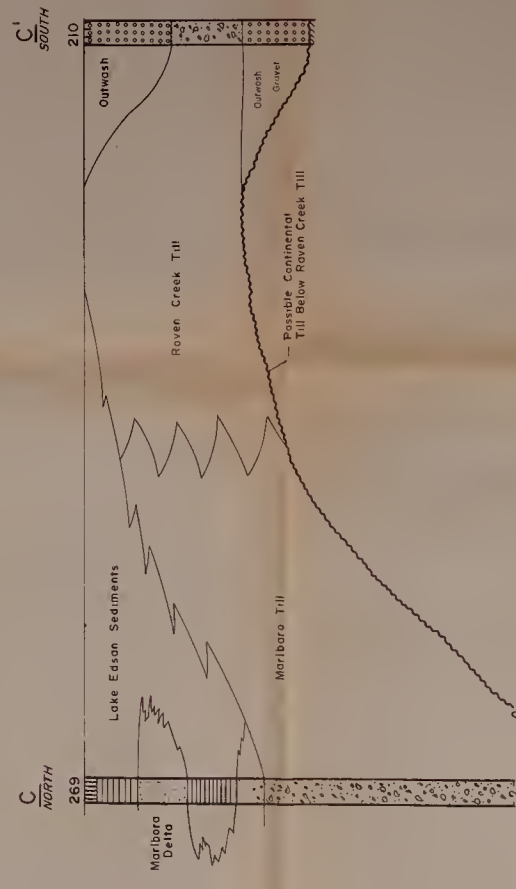
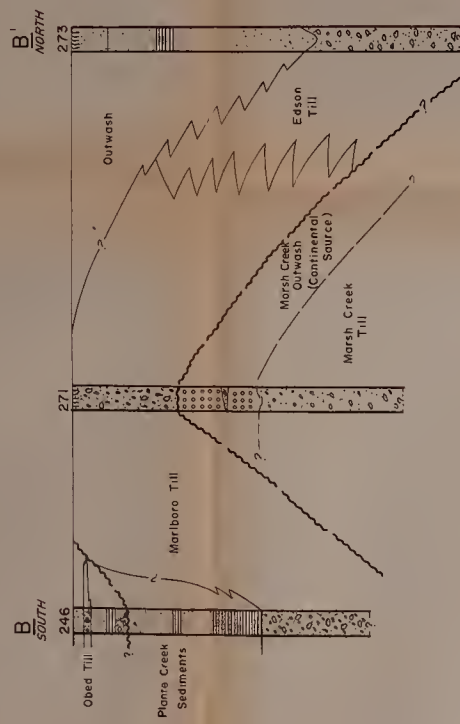
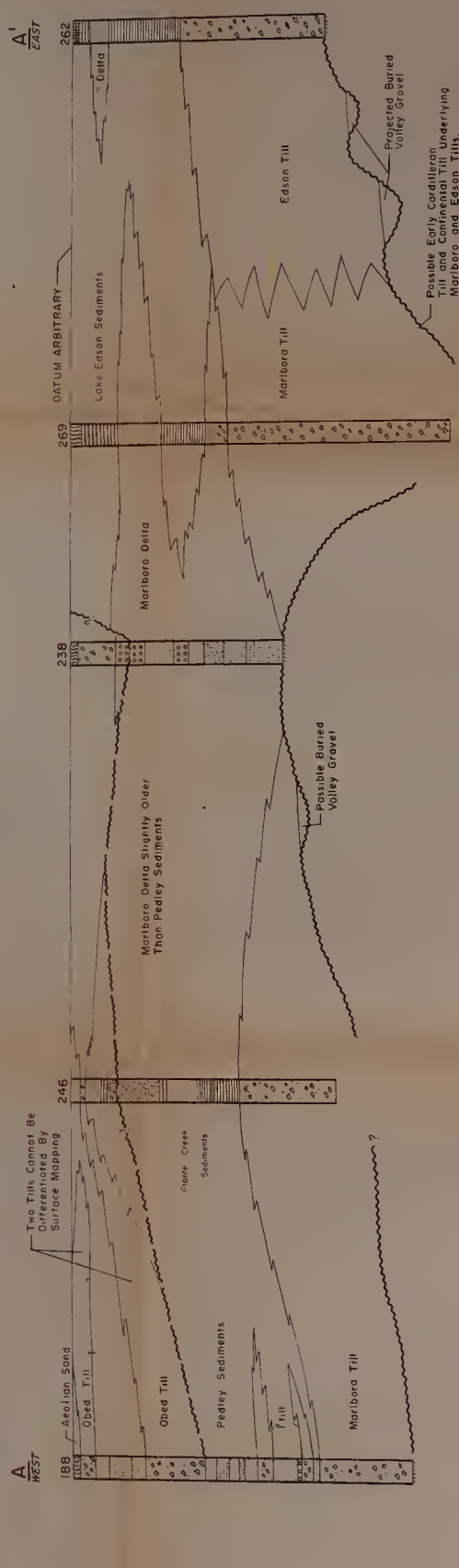


FIGURE 14

DIAGRAMMATIC CROSS-SECTIONS SHOWING STRATIGRAPHIC RELATIONSHIPS OF PRINCIPAL GLACIAL DEPOSITS

B29907